Gap Analysis for the Proposed He‘eia National Estuarine Research Reserve Programmatic EIS

A report of the Hawai‘i Office of Planning, Coastal Zone Management Program, pursuant to National Oceanic and Atmospheric Administration Award Nos. NA12NOS4190097 and NA14NOS4200130, funded in part by the Coastal Zone Management Act of 1972, as amended, administered by the Office of Ocean and Coastal Resource Management, National Ocean Services, National Oceanic and Atmospheric Administration, United States Department of Commerce. The views expressed herein are those of the author(s) and do not necessarily reflect the views of NOAA or any of its subagencies.

This document should be cited as:
Hawai‘i Office of Planning. 2015. Gap Analysis for the Proposed He‘eia National Estuarine Research Reserve Programmatic EIS. Draft. June 30, 2015. Prepared for the National Oceanic and Atmospheric Administration. Honolulu, Hawai‘i.

Executive Summary

The National Estuarine Research Reserve System (NERRS) is a network of 28 estuaries representing different biogeographic regions of the United States. NERRS is administered by the National Oceanic Atmospheric Administration (NOAA) and is a partnership between NOAA and the coastal states. Each National Estuarine Research Reserve (NERR) serves as a place-based living laboratory and classroom where research methods and management approaches can be piloted and applied to issues of local, regional, and national importance. NERRS, however, currently does not include a representative estuary from the insular (NERRS biogeographic region) Hawaiian Islands (NERRS insular biogeographic subregion).

In May 2014, the State of Hawai‘i (State) nominated He‘eia estuary in He‘eia, Kāne‘ohe, on the island of O‘ahu, to be part of NERRS. The total acreage of the nominated area is about 838 acres and includes He‘eia State Park (18.5 acres), He‘eia Fishpond (88 acres), He‘eia wetlands (about 200 acres), University of Hawai‘i Institute of Marine Biology property (28 acres) on Moku o Lo‘e (Coconut Island), and a large (503 acres) expanse of ocean with patch and fringing reefs.

The nomination was approved by NOAA, but prior to designating He‘eia estuary as a NERR, NOAA is required to comply with the National Environmental Policy Act (NEPA) and, in collaboration with the State, to draft an environmental impact statement (EIS). To conduct a comprehensive environmental analysis, NOAA needs information about the natural, cultural, and socioeconomic resources in the proposed action area, that is, the area in He‘eia that is officially nominated to be a NERR site. Lack of information can impede the NEPA process.

The purpose of this report (referred to herein as a *gap analysis*) is to determine whether currently available information is sufficient to analyze, at a program level, the environmental and social impacts of establishing a NERR at He‘eia in Hawai‘i, and to identify any information that is lacking.

For the gap analysis, two additional alternatives were analyzed in addition to the proposed action. Alternative 1 includes the proposed action area plus about 200 acres of upland area contiguous with the He‘eia wetlands. Alternative 2 includes the proposed action area plus additional outer reefs, contiguous and to the north of the marine portion of the proposed action area.

The gap analysis exercise involved three steps. First, data types were identified that would be needed to programmatically analyze, under NEPA, the natural, cultural, and socioeconomics aspects of the He‘eia NERR designation. Next, the required information was compiled, primarily from documented literature but also from members of the community and representatives of State and County agencies. Last, using subject matter expertise and applying knowledge of the topics typically analyzed under NEPA, the types of potential effects (e.g., direct or indirect take of listed species) that could occur through implementation of

the proposed action and the alternatives were identified. The information needed to support sound conclusions regarding the significance of potential effects was also identified; this included the criteria set forth in NOAA Administrative Order (NAO) 216-6 §6.01. If any of the data or information needed for the programmatic analysis was found missing, it was identified as a gap. The table at the end of this executive summary lists the topics analyzed and the potential effects of relevance to the NERR designation.

No information gaps were identified for natural or cultural resources: the existing and available data, inventories, interviews, research results, conservation guidance, and management measures are sufficient to analyze effects of the NERR designation at a program level. One socioeconomic gap was identified: resolution of community concerns about the potential for the NERR to increase environmental regulation and oversight and thus raise costs for local operations, or impose restrictions on community activities. These concerns would be assuaged by data or research from other NERRS sites. Data demonstrating that NERR designation does not impose new regulatory oversight or constraints, or increase costs for local operations, would be valuable to the programmatic NEPA analysis.

Gap Analysis Topics, and Potential Effect Types and Significance Criteria Identified

Topic	Potential Effect Type	Sufficient Information Available?
Habitat types: uplands, wetlands, freshwater stream, estuarine, coastal, and marine	• Effect on upland habitats—these could be significant if there was destruction of remnant native plant species in uplands or conversion of forest to grassland habitats in uplands. • Effects on wetlands—these could be significant if there were a net loss of wetland habitat due to conversion of wetland to upland, or degradation of wetland quality by invasive species. • Effects on freshwater, estuarine, and marine habitats—significant effects would include long-term reductions of species populations or their habitats, increased freshwater discharge rates, worsened water quality, spread of invasive species, and exacerbation of coral bleaching.	Yes
Threatened and endangered species	• Effects on listed plants, birds, marine mammals, marine reptiles, and terrestrial mammals—these could be significant if direct or indirect take of individuals or their habitats occurred or if invasive species caused cumulative effects in the action area.	Yes
Other flora and fauna	• Effects on native flora and fauna—these could be significant if population-level impacts or substantial habitat modifications occurred.	Yes
Watershed and hydrology	• Effects on watershed or hydrology—these could be significant if substantial changes occurred in the frequency or magnitude of peak flows in He‘eia Stream or in the impervious surface area in the He‘eia watershed.	Yes
Water quality	• Effects on water quality—these could be significant if the characteristics measured by Hawai‘i State water quality standards were substantially altered over baseline conditions.	Yes
Geological characteristics	• Erosion—effects could be significant if total suspended solids in receiving water bodies exceeded levels set by the State’s water quality standards.	Yes
Climate change	• Interactions between the proposed action and climate-related effects—significant effects could occur if the action caused a change in ecosystem resilience to climate change, or if climate change adversely affected project activities, such as with sea level rise and ocean acidification.	Yes
Cultural resources	• Effects on remains of documented archaeological sites, such as postcontact features—these could be significant if the sites were removed or modified. • Effects on as-yet undiscovered cultural resources—these would occur only if standard procedures for identifying and protecting discoveries were not followed.	Yes
Socioeconomics	• Effects on the local community—these could be significant if substantial changes to health, income, access to resources, or other indicators	No

	occurred; see discussion above for a description of the information gap identified.

Table of Contents

Figures

Tables

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Acronyms and Other Abbreviations

Abbreviation	Meaning
BMPs	best management practices
CFR	Code of Federal Regulations
chl-a	chlorophyll-*a*
CO_2	carbon dioxide
CZM	Coastal Zone Management
CZMA	Coastal Zone Management Act
DAR	Division of Aquatic Resources, DLNR
DBEDT	Hawai‘i State Department of Business, Economic Development and Tourism
DLNR	Hawai‘i State Department of Land and Natural Resources
DO	dissolved oxygen
DOBOR	Division of Boating and Ocean Recreation, DLNR
DOC	dissolved organic carbon
DOCARE	Division of Conservation and Resource Enforcement, DLNR
DOFAW	Division of Forestry and Wildlife, DLNR
DPS	distinct population segment
EA	environmental assessment
EIS	environmental impact statement
EO	Executive Order
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FWS	U.S. Fish and Wildlife Service
HAR	Hawai‘i Administrative Rules
HCDA	Hawai‘i Community Development Authority
HEPA	Hawai‘i Environmental Policy Act
HIDOH	Hawai‘i Department of Health
HIMB	Hawai‘i Institute of Marine Biology
HRS	Hawai‘i Revised Statutes
NEPA	National Environmental Policy Act
NERR	National Estuarine Research Reserve
NERRS	National Estuarine Research Reserve System
NH3	ammonia-nitrogen
NMFS	National Marine Fisheries Service
NO_3+NO_2	nitrate+nitrite-nitrogen

NOAA	National Oceanic and Atmospheric Administration
NWI	National Wetland Inventory
OP	Office of Planning, State of Hawai‘i
PCBs	polychlorinated biphenols
SEC	Site Evaluation Committee
SSC	Site Selection Committee
TMDLs	total maximum daily loads
TMK	Tax Map Key (number to identify real property unit)
TN	total nitrogen
TP	total phosphorus
TSS	total suspended solids
USC	United States Code
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
ZCTA	Zip Code Tabulation Unit (U.S. Census equivalent of Zip Code area)

Glossary of Hawaiian Words

The Hawaiian translations are from Pukui and Elbert (1986). For some of the words a more contemporary meaning may be used by Hawaiians today; for these words they are placed before the Pukui and Elbert (1986) translations and marked with "(common)."

The *ʻokina* and the *kahakō* are diacritical markings that are part of the Hawaiian alphabet and used in the Hawaiian words. The *ʻokina*, or glottal stop, is found only between two vowels or at the beginning of a word that starts with a vowel. A break in speech is created between the sounds of the two vowels. The pronunciation of the *ʻokina* is similar to saying "oh-oh." The *ʻokina* is written as a backward apostrophe. The *kahakō* is found only above a vowel. It stresses or elongates a vowel sound from one beat to two beats. The *kahakō* is written as a line above a vowel.

Hawaiian Word	English Translation
ahupuaʻa	Land division usually extending from the uplands to the sea, so called because the boundary was marked by a heap (ahu) of stones surmounted by an image of a pig (puaʻa), or because a pig or other tribute was laid on the altar as tax to the chief.
ʻauwai	Ditch, canal, water conveyance channels
hau	Lowland tree (Hibiscus tiliaceus), found in many warm countries, some spreading horizontally over the ground forming impenetrable thickets, and some trained on trellises.
kalo	Taro (Colocasia esculenta), a kind of aroid cultivated since ancient times for food, spreading widely from the tropics of the Old World. In Hawaiʻi, taro has been the staple from earliest times to the present, and here its culture developed greatly, including more than 300 forms.
leina ʻuhane	a place where the souls of the dead leaped into the nether world
loʻi	Irrigated terrace, especially for taro, but also for rice; paddy.
loko iʻa	Fishpond (common).
mele	chants
moʻolelo	Story, tale, myth, history, tradition, literature, legend, journal, log, yarn, fable, essay, chronicle, record, article; minutes, as of a meeting. (From moʻo ʻōlelo, succession of talk; all stories were oral, not written.)

Section 1. Purpose of This Gap Analysis

In May 2014, after a site selection process lasting one and a half years, the State of Hawai‘i (State) nominated He‘eia estuary in He‘eia, Kāne‘ohe, on the island of O‘ahu, to be part of the National Estuarine Research Reserve System (NERRS). NERRS is administered by the National Oceanic and Atmospheric Administration (NOAA) in partnership with the State. The mission of National Estuarine Research Reserve (NERR) Program is the establishment and management, through federal–state cooperation, of a national system of estuarine research reserves representative of the various regions and estuarine types in the United States. NERRs are established to provide opportunity for long-term research, education, and interpretation (Title 15, Code of Federal Regulations [CFR], Part 921.1[A]).

Upon approval of the site nomination, NOAA (through its Office for Coastal Management) is required to complete a series of actions before the site is designated. The action of designating a NERR site requires that NOAA comply with the National Environmental Policy Act (NEPA), and that a site-specific management plan be prepared by the collaborating state. For NEPA, an environmental impact statement (EIS) is being prepared to document the environmental impacts of designating the He‘eia NERR site. The EIS is being prepared by NOAA in collaboration with State of Hawai‘i Department of Business, Economic Development, and Tourism (DBEDT) Office of Planning (OP) (henceforth referred to as the State or OP) (PBR Hawai‘i 2014).

An EIS is a detailed document that assesses the environmental impacts of the proposed action. In this case, the action is designation of the He‘eia estuary as a NERR. The EIS for this action will include a description of significant environmental impacts that cannot be avoided if the action is implemented, alternatives to the proposed action, and mitigation measures considered and selected to minimize negative environmental effects.

For NOAA to conduct thorough environmental analyses of the effects of the proposed action and alternatives, sufficient information is needed regarding the natural, cultural, and socioeconomic resources in the proposed action area. If needed information is lacking, the NEPA process might be impeded (NOAA 2009). Therefore, the purpose of this report (referred to herein as a *gap analysis*) is to determine whether currently available information is sufficient to analyze, at a program level, the environmental and social impacts of establishing a NERR at He‘eia in Hawai‘i, and to identify any information that is lacking.

Section 2. Background on the Proposed National Estuarine Research Reserve at He‘eia

2.1 Project Background and History

The NERRS is a network of 28 estuaries representing different biogeographic regions of the United States that are protected for long-term research, water quality monitoring, education, and coastal stewardship. Established by the Coastal Zone Management Act (CZMA) of 1972, as amended, the NERRS is a partnership between NOAA and the coastal states. NOAA provides funding, national guidance, and technical assistance to support research. Each NERR is managed on a daily basis by a lead state agency or university, with input from local partners.

The NERRS mission is to practice and promote the stewardship of coasts and estuaries through innovative research, education, and training using a place-based system of protected areas. As a representative system, each reserve serves as a place-based living laboratory and classroom where research methods and management approaches can be piloted and applied to issues of local, regional, and national importance. Some examples of research being done at NERRs include the effects of pollutants on estuarine species, water quality studies, and fish migration studies.

Currently, the insular biogeographic region in the United States is not represented in the NERRS. This region comprises three subregions: the Hawaiian Islands, the Western Pacific Islands, and the Eastern Pacific Islands. With the designation of a NERR in Hawai‘i, the system would have a tenth region (of 11 total regions) and a twenty-second subregion (of 29 total subregions) represented.

In 1978, a NERR was designated in Hawai‘i, in the Waimanu Valley on the windward coast of the Big Island of Hawai‘i. The reserve was administered by the State Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife (DOFAW). Waimanu is a remote drowned river valley, accessible only by boat, helicopter, or a strenuous hike on a 9-mile switchback trail. The site’s inaccessibility was one of the reasons the Governor of Hawai‘i requested withdrawal of designation of this site in 1993 (PBR Hawai‘i 2014).

Governor Neil Abercrombie submitted a letter of interest in July 2012 to propose an expansion of the NERRS to include the unrepresented insular paleotropical region. He designated OP as the lead agency for the site selection process. The State Coastal Zone Management (CZM) Program, within OP, began the NERR site selection process for Hawai‘i in February 2013, per the process definition in 15 CFR 921. NOAA ultimately designates new NERRS sites, but coastal states are allowed to tailor the site selection process to suit regional sensibilities and the needs of the individual states’ CZM programs.

Phase I of the site selection process involved developing site selection criteria, forming a Site Selection Committee (SSC) to approve the criteria, forming a Site Evaluation Committee (SEC) to perform a technical review of proposed NERR sites, and soliciting proposals from the public. Proposals were received for two sites: Hilo Bay on the Big Island of Hawai‘i and He‘eia in Kāne‘ohe Bay on O‘ahu (PBR Hawai‘i 2014).

In Phase II, the SSC reviewed these two site proposals and was given all available information to consider. The committee selected He‘eia as the preferred site. The site selection document, including comments received from the public, was forwarded to the Governor in the first quarter of 2014. In May 2014, former Governor Abercrombie submitted a site nomination to NOAA. This nomination was approved by NOAA on October 27, 2014.

Phase III of the process involves drafting the EIS and developing a management plan for the He‘eia site.

2.2 Hawai‘i NERR Proposed Site Description

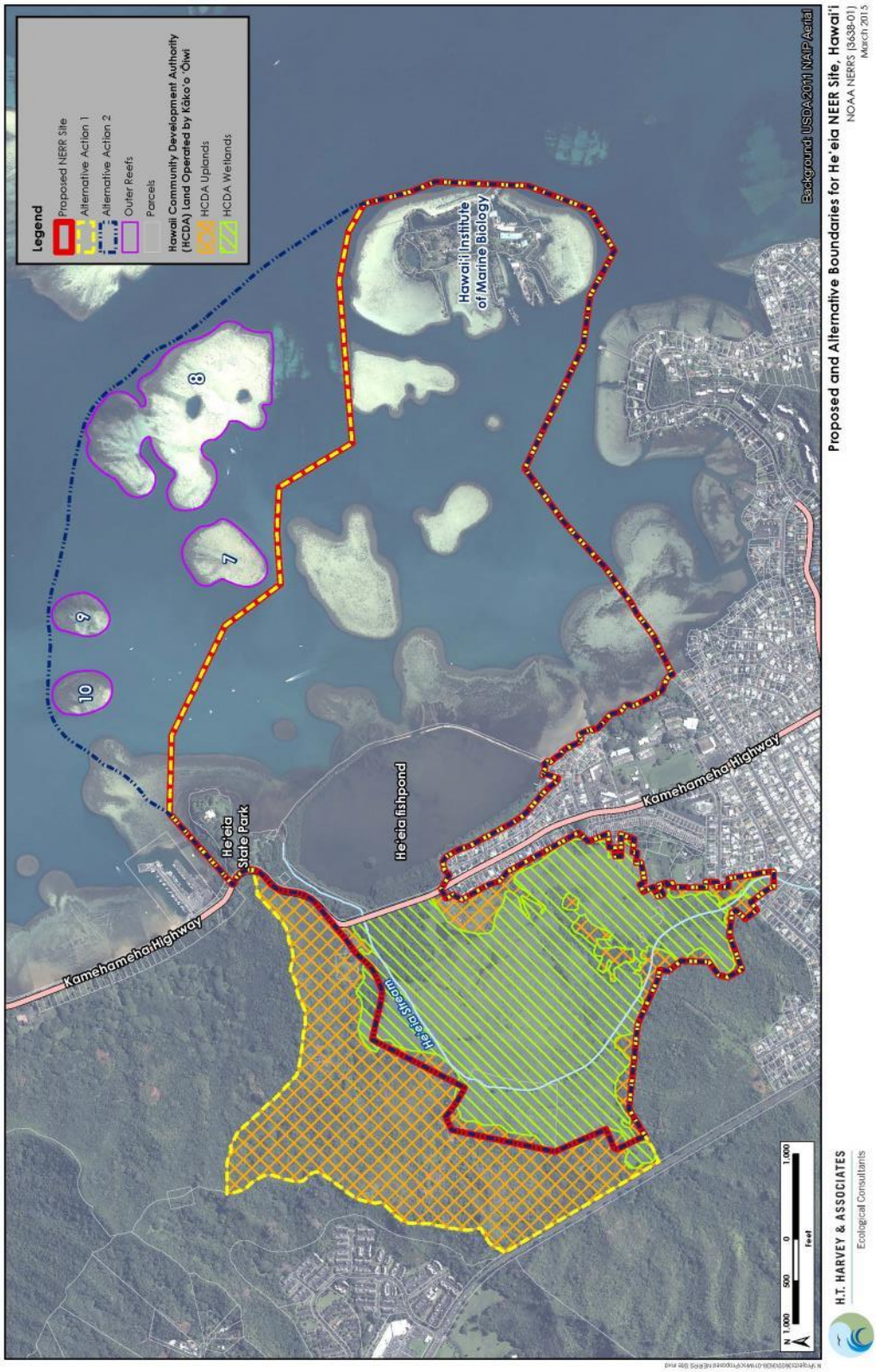
The He‘eia estuary is located in Kāne‘ohe Bay on the northeastern, or windward, shore of the island of O‘ahu. Kāne‘ohe Bay is the largest sheltered body of water in the Hawaiian Islands. The estuary is influenced by runoff from the surrounding watershed as well as by exchange of seawater from the ocean. Also, the semienclosed nature of the bay makes this estuary more vulnerable than an open coastline to damage by factors associated with urbanization and agricultural development (Jokiel 1991).

In the nomination document to NOAA, the area proposed as the He‘eia NERR was described as including the estuary, open ocean, and upland areas. The total acreage of the proposed site is about 838 acres and includes He‘eia State Park (18.5 acres) to the north, He‘eia Fishpond (88 acres) in the center, wetlands (about 200 acres) to the west and south, the University of Hawai‘i Institute of Marine Biology (HIMB) property (28 acres) on Moku o Lo‘e (Coconut Island) to the east, and the large (503 acres) expanse of ocean with patch and fringing reefs (Figure 2-1). For the purposes of the EIS, this area (proposed in the nomination document) will be designated and further analyzed as the location of the proposed action.

In December 2014, during the public scoping meetings for the NEPA process, NOAA received several comments requesting that the boundary of the proposed NERR include more upland areas as well as marine areas. As such, NOAA and the OP are considering additional alternatives for the NEPA analysis. The following two alternatives were identified by OP to include in this gap analysis report.

Alternative 1 includes the proposed action area plus about 200 acres of upland area contiguous with and north of the wetlands (Figure 2-1). Therefore, Alternative 1 would increase the reserve area by about 200 acres and would include within the NERR the entire parcel owned by the Hawai‘i Community Development Authority (HCDA).

Figure 2-1. He'eia NERR Proposed and Alternative Action Areas Considered in the Gap Analysis for the Programmatic EIS



Alternative 2 is the proposed action area plus the outer reefs, numbered 7, 8, 9, and 10, to the north of the marine portion of the proposed action area (Figure 2-1). These reefs are located in State-owned waters. The addition of these reefs and surrounding waters would increase the NERR site by approximately 302 acres.

The *no-action alternative* was not considered in this gap analysis because no additional information would be needed to analyze the no-action alternative beyond what is collected for analyzing the three action alternatives. It is known that several government and nongovernmental organizations in He‘eia (discussed in Section 2.3, “He‘eia Site Partners”) are actively conducting environmental research and cultural and natural resource projects in the region, such as restoration of the fishpond, removal of invasive plants, and restoration of traditional Hawaiian agricultural practices to the once productive upland and wetland habitats of He‘eia. These organizations have obtained the necessary permits to implement their strategic and management plans in the near future, irrespective of designation of He‘eia as a NERR. For the foreseeable future, conditions in the proposed He‘eia NERR site are not expected to evolve differently from that which would occur under the proposed action or alternatives. For example, if the site were designated a NERR, the currently planned projects would not be inhibited or precluded. And, if the site were not designated a NERR, it is unlikely that the area would be developed or habitat degraded, owing to the ongoing independent restoration projects.

This gap analysis for the He‘eia NERR is being conducted as part of Phase III of the site selection process described above. As discussed in Section 1, the purpose of this gap analysis is to determine whether currently available information is sufficient to identify, at a program level, the environmental, cultural, and socioeconomic impacts of establishing a NERR at He‘eia. The analyses to identify information gaps in this report were conducted for all three action alternatives described above.

2.3 He‘eia NERR Site Partners

The nomination of He‘eia estuary as a NERR site is supported by many organizations such as Kāko‘o ‘Ōiwi, Paepae o He‘eia, HIMB, He‘eia State Park, Ko‘olau Foundation, and the Ko‘olaupoko Hawaiian Civic Club, whose collective commitment is the conservation and restoration of Kāne‘ohe Bay. As detailed below, these groups bring expertise and commitment to provide solutions for restoring and protecting the bay.

- Kāko‘o ‘Ōiwi is a 501(c)3 nonprofit organization that has entered into a 38-year lease with landowner HCDA (Figure 2-1). The HCDA lands encompassed by the proposed action and Alternative 1 were once very productive lands in Kāne‘ohe, with hundreds of acres of taro lo‘i (taro fields) along He‘eia Stream. Kāko‘o ‘Ōiwi plans to restore the cultural, environmental, and agricultural significance of this place. Its proposed project, Māhuahua ‘Ai o Hoi (“to restore the fruit of Hoi”), will establish a land management program to restore the wetlands of He‘eia, also known as “Hoi,” to productive agricultural use. The purpose of this project is to feed the community and sustain its culture and economy, and to improve the health of wetlands and coastal areas.

- Paepae o Heʻeia is a private nonprofit organization dedicated to caring for Heʻeia Fishpond, an ancient Hawaiian fishpond located in the center of the proposed action area. Paepae o Heʻeia has a lease from the owner, Kamehameha Schools, to manage and maintain Heʻeia Fishpond for the community.

- HIMB is located on Moku o Loʻe in Heʻeia, which is owned and operated by the University of Hawaiʻi. HIMB conducts multidisciplinary research and education in all aspects of marine biology.

- Heʻeia State Park is owned by the State of Hawaiʻi and is currently managed by Kamaʻaina Kids, an organization that conducts various waterfront and environmental education programs in Kāneʻohe.

- The Koʻolau Foundation is a cultural heritage preservation program with a mission to promote Hawaiian cultural and environmental practices, preservation, and education.

- The Koʻolaupoko Civic Club, established in 1937, is part of the State Association of Hawaiian civic clubs and perhaps one of the oldest organizations in the state. This civic club continues its effort to support the culture and heritage of native Hawaiians through its educational and service programs, community outreach, and participation in the Association of Hawaiian Civic Clubs.

Section 3. Gap Analysis Approach

3.1 Overview of Approach

The gap analysis process was started by compiling information on the natural, cultural, and socioeconomic aspects of He‘eia watershed. Whenever necessary, project stakeholders, including representatives of State and County of Honolulu agencies and members of the community, were consulted and interviewed to collect additional information. By considering NEPA requirements and using subject matter expertise, the types of potential effects that could occur through implementation of the proposed action or alternatives were identified. Compiled information was then analyzed to identify if there were any gaps in the information necessary to analyze the direct, indirect, and cumulative effects, at a program level, of the proposed and alternative actions. This overall approach is further described below. As noted in Section 2.2, no information gaps are expected to affect analysis of the no-action alternative, so this alternative is not discussed to the same extent as the proposed action and other alternatives.

3.2 Step 1: Collection of Data and Information

The following types of data were gathered to assess the completeness of current information regarding environmental, cultural, and socioeconomic conditions in the action area:

- Natural resources
  - Habitat types and descriptions (aquatic and terrestrial)
  - Endangered and threatened species (federally and State-listed) and records of occurrence
  - Distribution and abundance of flora and fauna
  - Watershed and hydrology
  - Water quality
  - Geology
  - Climate
- Cultural resources
  - Archaeological feature types and descriptions
  - Cultural sites and descriptions
  - Archival historical documentation
  - Oral history interviews
  - Mo‘olelo and oli Mo‘olelo (Hawaiian-based historical accounts) and mele (chants)
- Socioeconomics
  - Current demographic and economic characteristics of the population living in the vicinity of the proposed action area, and in the surrounding community
  - Demographic and economic trends in the surrounding community
  - Recent traffic levels on major roadways

- Projected population and economic trends in the surrounding community
- Likely trends in recreation, commercial activity, and traffic in the surrounding community
- Property development and values in the surrounding community
- Investment of human capital and funds for research, education, subsistence, and recreation activities in the proposed action area, and future projections (independent of the NERR designation)

3.3 Step 2: Compilation of Data and Information

3.3.1 Natural Resources

A thorough review was conducted of previous studies in Heʻeia and Kāneʻohe Bay that addressed the natural resource topics identified above. Information on natural resources was compiled primarily from a review of literature, including books, journal articles, technical reports, government documents, and other scientific literature regarding flora, fauna, habitat types, water quality, hydrology, watershed, geology, and climate in Kāneʻohe Bay and, where possible, within the Heʻeia watershed. Online spatial databases such as the National Wetland Inventory (NWI) and the U.S. Fish and Wildlife Service's (USFWS's) Critical Habitat Mapper were used in conjunction with the printed resources. When necessary, agencies such as the Hawaiʻi Department of Health (HIDOH) were contacted to gather unpublished information.

3.3.2 Cultural Resources

Information on cultural resources was compiled from existing literature. Research was done at the library that holds archaeological reports at the Hawaiʻi State Historic Preservation Division. Additional archaeological reports were received from the community and private organizations. These reports document all previous work done in the Heʻeia watershed and surrounding areas and list known archaeological and cultural sites, including historical architectural features.

3.3.3 Socioeconomic Characteristics

Socioeconomic characteristics were studied using U.S. Bureau of the Census data, Hawaiʻi data collected for the State or County on fishing and agricultural production, State of Hawaiʻi and City and County of Honolulu data on the use of roadways, and State and County projections of population and economic change in areas within Hawaiʻi. Interviews with local experts, including major stakeholders in preservation projects in the proposed action area, helped to establish current levels of activity, likely future activities with or without NERR designation, and anticipated impacts on the surrounding community.

3.4 Step 3: Gap Analysis and Recommendations

Section 4 describes and analyzes the available information on natural, cultural, and socioeconomic aspects of Heʻeia. To some extent, the summaries discuss not just current but various future activities planned by the organizations in Heʻeia, supporting the conclusion that available information on the no-action alternative is sufficient.

To identify gaps in the compiled information that would impede a programmatic analysis of direct, indirect, and cumulative effects, the types of potential effects were first identified (see the example in Table 3-1, first column). These types of potential effects were identified based on the known natural and cultural resources, environmental conditions, and socioeconomic conditions in He‘eia, and by applying knowledge of the topics typically analyzed under NEPA and any additional impact topics deemed to have relevance to the action. The thresholds at which each effect would be considered significant and adverse also were considered, in order to pinpoint the scale and type of data or information needed to determine significance (see Section 3.4.1 below).

Subject matter experts then identified the information that would be needed (Table 3-1, second column) to support sound conclusions regarding the significance of potential effects. The geographic extent of effects was determined separately for each topic or resource, to adequately account for how the NERR designation may have consequences outside the boundaries of the action area. Lastly, this list of required information was compared to the compiled inventory of currently available information (Table 3-1, third column) to identify what is still needed for the programmatic NEPA analysis. The gaps are listed separately for the proposed action and Alternatives 1 and 2 (Table 3-1, fourth, fifth, and sixth columns).

Table 3-1. Gap Analysis Sample Table

			Is Sufficient Information Available?		
Potential Effect	**Type and Scale of Information Needed to Support Significance Determination**	**Existing Sources**	**Proposed Action**	**Alt. 1: Boundary Expansion (Uplands, Entire HCDA Parcel)**	**Alt. 2: Boundary Expansion (Outer Reefs)**
Direct or indirect take of listed marine reptiles or their habitat	Distribution and status of green sea turtles in Kāne‘ohe Bay	Balazs et al. 1998, Francke et al. 2013: These sources state that the National Marine Fisheries Service continues to assess the health and stability of green turtles in Kāne‘ohe Bay, with an emphasis on assessing quality foraging resources, disease occurrence and prevalence, and outreach efforts designed to minimize risk and avoid take.	Yes	Yes	Yes

3.4.1 Determining Significance

The following list from NOAA Administrative Order (NAO) 216-6 §6.01 described factors that should be considered when determining significance for all NOAA actions:

A. Impacts may be both beneficial and adverse; a significant impact may exist even if the federal agency believes that on balance the impact will be beneficial.

B. Degree to which public health or safety is affected.
C. Unique characteristics of the geographic area.
D. Degree to which impacts on the human environment are likely to be highly controversial.
E. Degree to which impacts are highly uncertain or involve unique or unknown risks.
F. Degree to which the action establishes a precedent for future actions with significant impact or represents a decision in principle about a future consideration.
G. Individually insignificant but cumulatively significant impacts.
H. Degree to which the action adversely affects entities listed in or eligible for listing in the National Register of Historic Places, or may cause loss or destruction of significant scientific, cultural, or historic resources.
I. Degree to which endangered or threatened species, or their critical habitat as defined under the Endangered Species Act of 1973, are adversely affected.
J. Whether a violation of federal, state, or local law for environmental protection is threatened.
K. Whether a federal action may result in the introduction or spread of a non-indigenous species.

For each of the resource topics discussed in Section 4, impact types and significance thresholds were identified in accordance with the broad criteria listed above. For example, if an alternative's impacts were considered likely to meet Criterion B (effects on public health or safety), Criterion E (impacts that are highly uncertain or involve unique or unknown risks), or Criterion I (impacts that affect threatened or endangered species, or their critical habitat), those issues were noted as impact types for which measurable thresholds will be applied in the NEPA analysis of effects.

Section 5 identifies the information gaps that need to be addressed in order to develop the programmatic EIS. In summary, only one information gap, relating to baseline socioeconomic data, was identified. Section 5 makes recommendations regarding research necessary to address this information gap prior to completion of the EIS. Also, the section provides recommendations for research or studies on future site-specific projects, to support their future compliance with NEPA or the Hawai‘i Environmental Policy Act (HEPA).

Section 4. Summary of Available Information

4.1 Habitats

4.1.1 Upland Habitats

Upland areas in the proposed action area boundary comprise (1) forested areas at Heʻeia State Park (19 acres), (2) undeveloped and landscaped areas between the Heʻeia Fishpond and the residential neighborhood (about 9 acres), (3) emergent lands on Moku o Loʻe (28 acres), and (4) natural uplands and fill areas in wetlands on the HCDA property (approximately 15 to 20 acres west of Kamehameha Highway) (Figure 4-1). Compared to the proposed action, Alternative 1 would add about 200 acres of uplands contiguous with and north of the HCDA wetlands (Figure 4-1). Under Alternative 2, there would be no change in the area of uplands that would be part of the NERR.

The upland habitats in Heʻeia State Park, around the residential units, and on Moku o Loʻe are modified, and reported to support a few native plants and animals, but no rare, threatened, or endangered species (Weissich 1993). The northern part of Heʻeia State Park comprises landscaped habitats, manicured lawns, and a wide variety of introduced and exotic tree and shrub species (PBR Hawaiʻi 1993) (Figure 4-2).

The upland areas around the residences (between the residential community and the Heʻeia Fishpond) are dominated by a mosaic of landscaped and weedy habitats. The landscaped areas consist of mowed lawns and ornamental plant species, either being actively cared for or in various stages of disrepair (LeGrande 2006). A patch of dense indigenous hau (*Hibiscus tileaceous*) forest grows in this part of the action area (Brooks 1991, LeGrande 2006). The fallen leaves and other vegetative matter in the hau forest are rarely dry, because of the thick canopy cover of the hau trees. The moist ground cover is believed to create habitat for mosquitoes and other insects, which in turn may serve as food for juvenile fish in the adjacent mangrove habitats (Brooks 1991). Upland habitats on Moku o Loʻe also are highly modified, by past and ongoing land uses. These habitats contain a mosaic of open scrub vegetation with scattered trees, which are predominantly nonnative (Char & Associates 1994, 1995; SWCA 2013).

Some upland areas are located in the southern half of the HCDA lands, which are otherwise predominantly wetlands. These upland areas occur in the southwestern part of the proposed action area, near the residential neighborhoods, along Kamehameha Highway, and on Kealohi Road, an unpaved road that runs along the foothill bordering the wetlands (Figure 4-1). There is a demonstration taro loʻi in the southwestern part of the wetlands, and Kākoʻo ʻŌiwi plans to construct supporting agricultural and community facilities in the remaining upland areas, including a poi mill, composting facility, community center, health center, Hawaiian hale (house), and baseyards (Townscape 2011a, 2011b). Photographs of the upland areas reveal a grassland habitat interspersed with shrubs and trees (Townscape 2011a). The vast majority of plants and

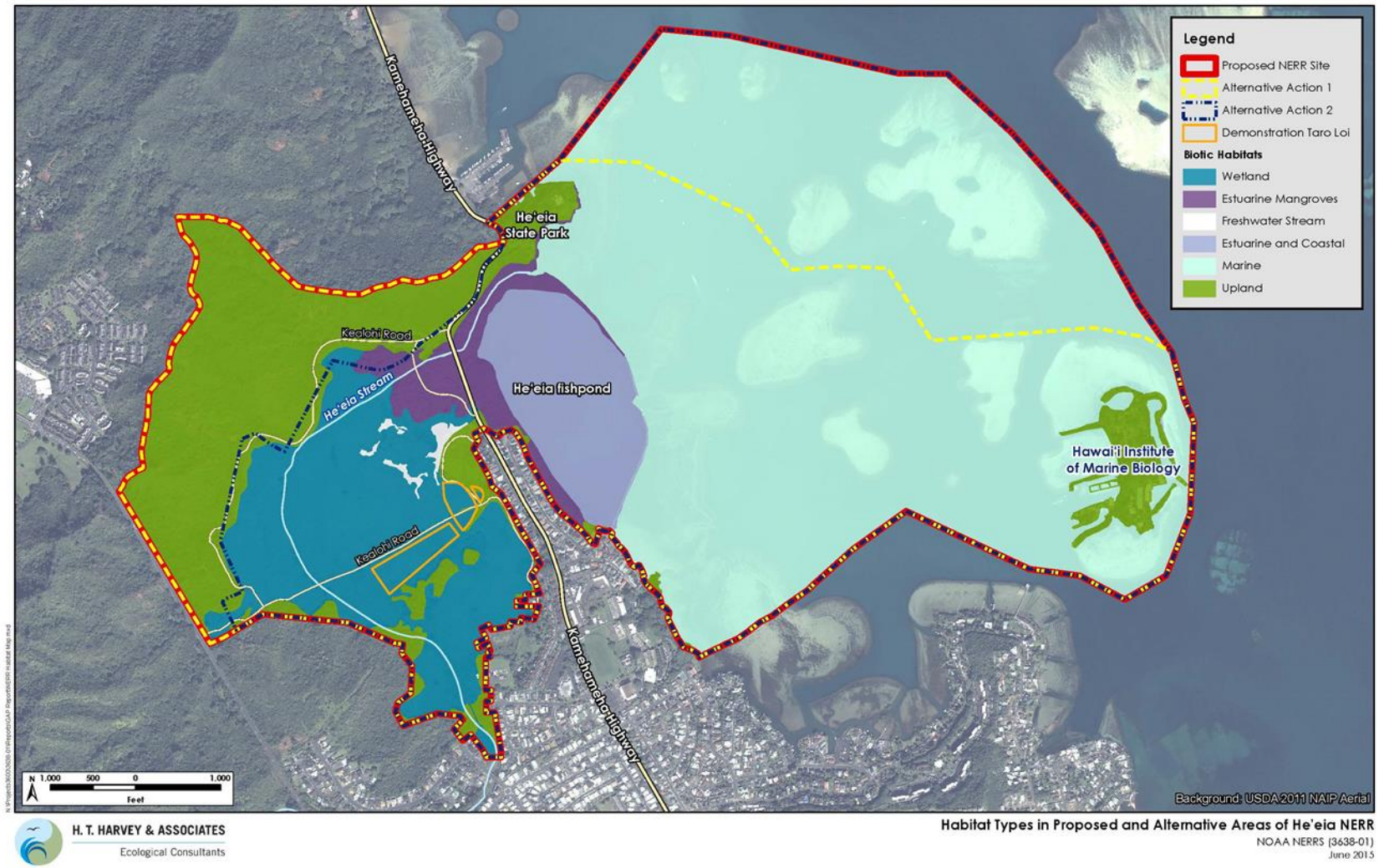


Figure 4-1. Habitat Types in He‘eia Proposed and Alternative Action Areas

Figure 4-2. Landscaped Upland Habitat at He‘eia State Park with Monkey Pod (Samanea saman) and Coconut (Cocos nucifera) Trees (December 16, 2014)

animals identified in a recent biological survey (Townscape 2011a) of these upland habitats were nonnative invasive species, indicating the disturbed and degraded nature of these habitats. Prior biological surveys (Krauss 1976, Lamoureux 1983, Calvin and Kim 1990) in and around the upland areas also found these habitats to be dominated by cultivated and nonnative escaped ornamental shrubs and trees and weedy herbaceous plants, indicating a long history of disturbance (Figure 4-3).

Figure 4-3. Upland Habitats Bordering the He‘eia Wetlands, Dominated by Ornamental and Cultivated Species Like Ulu (Artocarpus altilis), Banana (Musa sp.) and Coconut (Cocos nucifera) (December 16, 2014)

Alternative 1 would add about 200 acres of forested land at the foothills of the Koʻolau Mountains. Past deforestation and land clearing for agriculture and urban development has resulted in significant erosion of these upland habitats. In the steeper areas, the land has slopes of 25 to 40%, and the soils on these hillsides are considered highly erodible, with bare landslide areas visible in many places (see Section 4.6, "Geology"). These upland areas currently are used illegally by hunters and dirt bike riders, whose activities continue to exacerbate the soil erosion problem (Townscape 2011a); control of these actions is at the discretion of the landowner. The upland forests support mostly invasive trees such as Java plum (*Syzygium cumini*), strawberry guava (waiawī, *Psidium guajava*), ironwood (paina, *Casuarina equisetifolia*), octopus tree (*Schefflera actinophylla*), and koa haole (*Leucaena leucocephala*) (Krauss 1976, Lamoureux 1983, PBR Hawaiʻi 1993, Townscape 2011a). *Albizia* trees in the uplands are a safety concern because of their propensity to drop branches and fall over. Through its Māhuahua ʻAi o Hoi Project, Kākoʻo ʻŌiwi plans to conduct forest restoration and cultivate dryland crops, medicinal and ornamental plants, and orchards with fruit trees like banana (maia, *Musa* x *paradisiaca*) and breadfruit (ulu, *Artocarpus altilis*) (Townscape 2011a, 2011b).

Effect Types and Significance Criteria

Because most of the upland areas are zoned for conservation, and because some upland areas, such as those around the fishpond, have historical significance (Helber Hastert & Fee 2007), the loss or degradation of upland habitat due to urban development is considered unlikely, regardless of whether the area is designated as a NERR. No activities in the upland habitats are planned under the proposed action or under Alternative 1. However, potential effects on upland habitats could be considered significant if ongoing activities such as agriculture, aquaculture, restoration, or construction of low-impact facilities being planned and developed by Kākoʻo ʻŌiwi led to the direct or indirect loss of the remaining native plant species or caused the conversion of upland forest-type habitat to grasslands or bare earth. Also, the chance of fire spreading into the upland habitats would be higher with even low-impact construction activities. Furthermore, the chances of inadvertently causing the introduction and spread of invasive species that can change upland vegetation communities are greater under any scenario that involves the movement of dirt, building material, plants, or plant propagules for habitat restoration.

Conversion of diverse forested uplands to monotypic grasslands would be considered adverse because of decreased watershed services, the higher propensity of grasslands to carry fire, ad changes in the biogeochemistry of the upland habitats (D'Antonio and Vitousek 1992, Asner and Beatty 1996). Furthermore, because the terrestrial uplands within the uplands boundary expansion area (Alternative 1) have highly erodible soils (Townscape 2011b), actions that occur in this area in particular could result in loss of vegetative cover and increased bare ground.

Table 4-1. Information Available for Analysis of Upland Habitat Effects

Potential Effect	Type and Scale of Information Needed to Support Significance Determination	Existing Sources	Is Sufficient Information Available?		
			Proposed Action	Alt. 1: Boundary Expansion (Uplands, Entire HCDA Parcel)	Alt. 2: Boundary Expansion (Outer Reefs)
Destruction of remnant native plant species in the uplands	• Distribution and composition of upland habitats • Details on existing and planned land management activities	• Krauss 1976, Lamoureux 1983, Calvin and Kim 1990 Brooks 1991, PBR Hawai‘i 1993, LeGrande 2006, Townscape 2011a and b, SWCA 2013: These sources have described the distribution and the composition of the upland habitats, including the distribution of the remnant native plant species. Townscape (2011a and b) have discussed the activities planned by Kāko‘o ‘Ōiwi in the upland habitats that involve enhancing the population of remnant native plant species.	Yes	Yes	Yes
Conversion of upland forests to grasslands or bare earth	• Distribution and composition of upland habitats • Details on existing and planned land management activities	• Krauss 1976, Lamoureux 1983, Calvin and Kim 1990 Brooks 1991, PBR Hawai‘i 1993, LeGrande 2006, Townscape 2011a and b, SWCA 2013: These sources describe the distribution and composition of upland forest habitats. Townscape (2011a and b) discuss how Kāko‘o ‘Ōiwi plans to convert limited upland habitats (at the foothills and not in steeper parts) gradually and in phases to orchard, avoiding erosion and the establishment of invasive weeds.	Yes	Yes	Yes

Notes: Alt = Alternative; HCDA = Hawai‘i Community Development Authority.
Yes = Existing sources are sufficient for analysis.

4.1.2 Wetlands

The wetlands of He‘eia are fed by the waters of Haiku Stream and Iolekaa Stream, which converge upstream of the wetlands to form the He‘eia Stream. According to the NWI, five types of wetlands occur within the proposed action and alternative NERR boundaries: (1) estuarine and marine deepwater, (2) freshwater emergent, (3) estuarine and marine wetland, (4) freshwater forested/shrub, and (5) freshwater pond (USFWS 2015a) (Figure 4-4). Except for estuarine and marine deepwater wetlands, these different types

of wetlands occur on (1) HCDA lands to the west of Kamehameha Highway, (2) along the banks of the He‘eia Stream in He‘eia State Park, and (3) along the northwestern, western, and southwestern walls of the fishpond (Figure 4-4) (USFWS 2015a). The wetland types and locations are further described below, except for estuarine and marine deepwater wetlands, which are discussed under Section 4.1.5, “Coastal and Marine Habitats.”

The HCDA lands contain four out of the five wetland types identified by NWI: estuarine and marine wetland, freshwater emergent, freshwater forested/shrub, and freshwater pond (Figure 4-4). These wetlands encompass about 200 acres and are leased to Kāko‘o ‘Ōiwi, which plans to restore the wetlands’ cultural, environmental, and agricultural significance and health through its Māhuahua ‘Ai o Hoi project. All three action alternatives include the wetlands on HCDA lands, with the western part of the proposed action boundary almost running parallel to He‘eia Stream (Figure 4-4).

Estuarine and marine wetlands occur in the northern part of the HCDA wetland area, and largely comprise thick mangrove swamp (Calvin Kim and Associates 1990, Brooks 1991, PBR Hawai‘i 1993, U.S. Department of Agriculture [USDA] 2011). Red mangrove (*Rhizophora mangle*), introduced to the area around 1910, is the dominant species, followed by the *Bruguiera* species *B. sexangula* and *B. gymorhiza.* The expansion of mangroves and deposition of sediments over time has reduced the estuarine environment and altered water flow pattern with respect to both the stream channel locations and the extent of tidal water incursions. Although the mangroves are not native, they are known to harbor a variety of marine and estuarine organisms that are sought for bait and food. The habitat provided by the mangrove prop roots and associated fouling assemblages (e.g., algae, invertebrates) provide habitat for juvenile fish which, as adults, populate freshwater or marine environments (Calvin Kim and Associates 1990, Brooks 1991).

The expansion of mangroves also has substantially reduced the area of marshland habitat once used by native waterbirds (Calvin Kim and Associates 1990, Brooks 1991, Helbert Hastert & Fee 2007). Kāko‘o ‘Ōiwi, through its Māhuahua ‘Ai o Hoi Project, plans to remove approximately 20 acres of the mangroves that are choking the stream channel, and to replace them with native sedges that will serve as habitat for birds and as a nursery for juvenile fish (Townscape 2011a, 2011b). As discussed in Section 4.2, the endangered Hawaiian hoary bat (‘ope‘ape‘a, *Lasiurus cinereus semotus*) likely roosts in the mangroves (Helber Hastert & Fee 2007, SWCA 2013), so removal of the mangroves will be conducted outside of the bat’s breeding season to avoid impacts on the species. The project also includes a predator control program for rats, mongooses, cats, and dogs, and a monitoring program for the early identification and response to sightings of avian botulism (Townscape 2011a, 2011b).

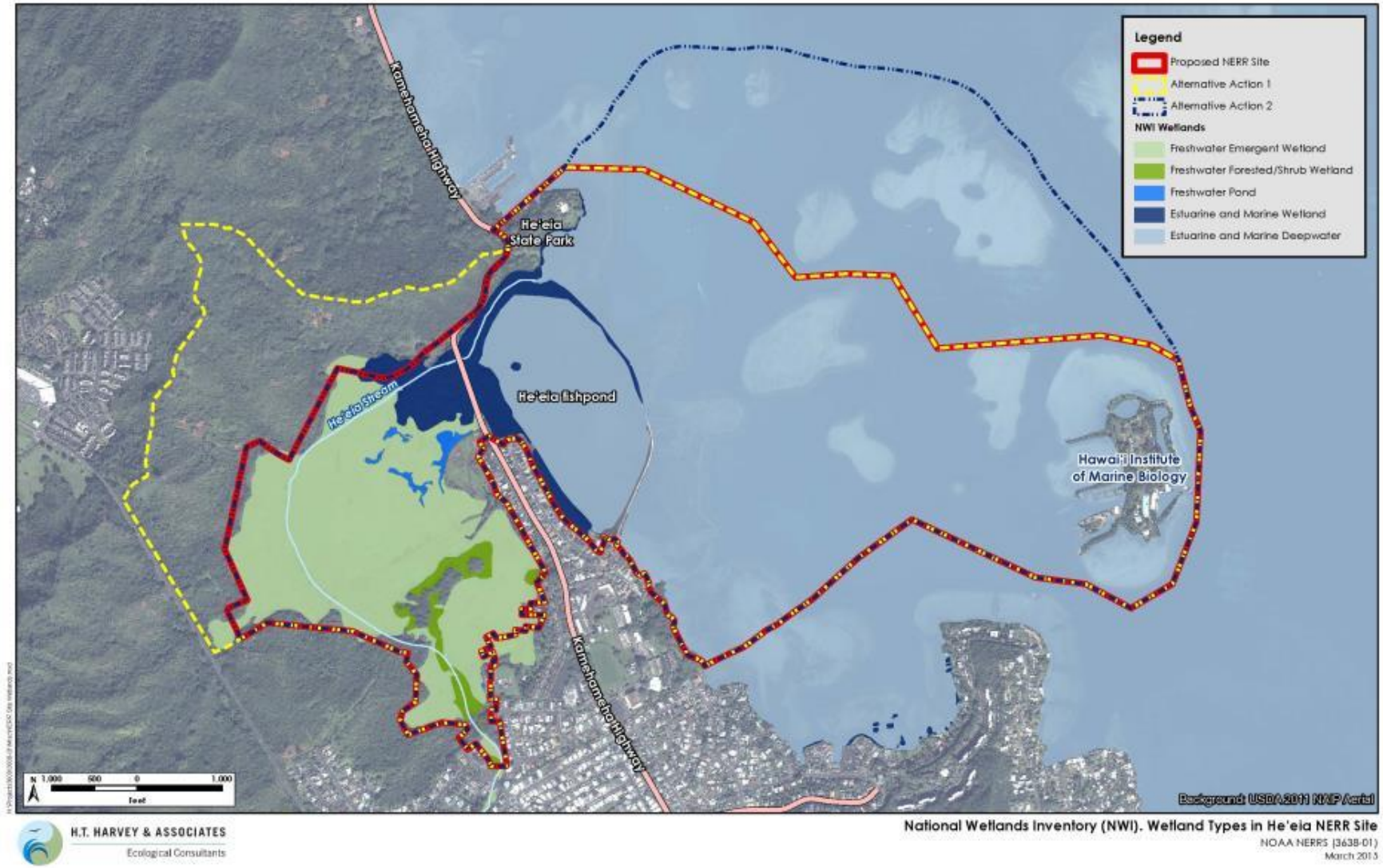


Figure 4-4. Wetland Types in the He‘eia Proposed and Alternative Action Areas

The vast majority (about 170 acres) of HCDA lands above the mangrove swamp is freshwater emergent wetland (Figure 4-4) and comprises He‘eia Stream, marsh, and seasonally wet grasslands (Calvin Kim and Associates 1990, Townscape 2011a). He‘eia Stream, along the southwestern boundary of the proposed action area, is lined with a dense forest of hau trees. Almost throughout its course in the wetlands, the stream is choked by California grass (*Urochloa mutica*) and other invasive species that impede its flow and water quality (Townscape 2011a, HIDOH 2014). The stream currently provides poor habitat for waterbirds and does not allow fish passage. After studying the stream’s hydrology and hydraulics, Kāko‘o ‘Ōiwi plans to restore the stream channels to create habitat for native aquatic fish, shrimp, and other organisms now absent from the stream. Whether dredging of the stream will be needed has not been determined (Townscape 2011a). Kāko‘o ‘Ōiwi also plans to create detention ponds toward the southern end, where the stream enters the HCDA property. The detention ponds are planned to be approximately 10 to 15 acres, and will help slow down or detain the stormflows that enter the wetland, thereby reducing impacts on the wetland.

The marsh habitat consists mostly of the floodplain of the He‘eia Stream west of the mangrove swamp. It is extensively overgrown with California grass, which occludes open-water areas (Calvin Kim and Associates 1990, Townscape 2011a, USDA 2011). The marsh habitat is known to occasionally provide feeding and loafing habitat for the Hawaiian gallinule (‘alae ‘ula, *Gallinula chloropus sandvicensis*), Hawaiian duck (koloa maoli, *Anas wyvilliana*), Hawaiian coot (‘alae kea, *Fulica alai*), and Hawaiian stilt (ae‘o, *Himantopus mexicanus knudseni*). The dense growth of California grass in the He‘eia marsh (Figure 4-5) is believed to have a greater negative impact on native waterbird habitat than the mangrove swamp (Calvin Kim and Associates 1990, Townscape 2011b).

Figure 4-5. Dense Growth of California Grass (Urochloa mutica) in He‘eia Marsh Habitat (December 16, 2014)

Seasonally wet grasslands form the floodplain east of the He‘eia stream. They flood and become marshy in the rainy season, when they are covered by up to 1 foot of water (Calvin Kim and Associates 1990). Dominated by California grass, these seasonally wet grasslands also support a variety of nonnative facultative and obligate wetland plant species.

The freshwater forested/shrub type wetland occurs within a narrow belt around the upland habitat located in the southern part of the HCDA wetlands (Figure 4-4). The forested/shrub wetlands comprise trees like java plum (*Syzygium cumini*) and shrub species such as cat’s claw (puakelekino, *Caesalpinia decapetala*), Cuba jute (*Sida rhombifolia*), koa haole, and guava (*Psidium guajava*). At the southern boundary of the proposed action area, where Heeia Stream enters the HCDA wetlands, this wetland type comprises thick hau forest (Townscape 2011a, 2011b).

Freshwater pond wetlands are represented by natural open-water ponds located inland from the mangrove forests (Figure 4-4). These ponds have mixed native and nonnative vegetation; native plants present include makaloa (*Cyperus laevigatus*) and neke (*Cyclosorus interruptus*) ferns (Townscape 2011a).

In cooperation with the Natural Resources Conservation Service, Kāko‘o ‘Ōiwi has developed a detailed conservation plan, the implementation of which is in progress. This includes restoring 12 acres of wetland to taro lo‘i in the southern part of the HCDA wetlands (Townscape 2011b) (Figure 4-6). The conservation plan comprehensively addresses concerns regarding the soil, water, animals, plants, and air resources involved in the 12-acre restoration of wetland to taro lo‘i.

Figure 4-6. Taro Lo‘i in He‘eia Wetlands (December 16, 2014)

In addition to taro lo‘i, Kāko‘o ‘Ōiwi’s long-term plan includes restoration of approximately 10 acres of loko i‘a kalo in the northern, wetter part of the marsh, immediately adjacent to the mangrove swamp. Loko

iʻa kalo is the Hawaiian traditional agricultural practice of combining taro fields and fishponds in brackish areas. As well as producing fish and taro, the loko iʻa kalo is expected to enhance native waterbird habitat and act as a sediment trap during rain events (Townscape 2011a). Just north of the loko iʻa kalo, Kākoʻo ʻŌiwi plans to establish an aquaculture or aquaponics facility on about 1 acre.

The wetlands on the east side of Kamehameha Highway are mostly of the estuarine and marine type, and occur along the banks of the Heʻeia Stream in Heʻeia State Park and along the north, west, and south walls of the fishpond (Figure 4-4). Similar to the estuarine and marine wetlands on the HCDA lands, this area largely comprises a dense mangrove swamp (Calvin Kim and Associates 1990, Brooks 1991, PBR Hawaiʻi 1993). Right before entering the ocean, Heʻeia Stream flows through the southern part of Heʻeia State Park. The banks of the stream are crowded by the invasive red mangrove and *Bruguiera* species (*B. sexangula* and *B. gymorhiza*) (Figure 4-7). This mangrove habitat functions as a trap for nutrients and sediments from Heʻeia Stream and confines saltwater intrusion to the east side of Kamehameha Highway. As discussed above, the mangrove habitats have considerably reduced the estuarine environment by altering the streamflow and the extent of tidal water incursions (Calvin Kim and Associates 1990, Townscape 2011a). The expansion of mangroves also had substantially altered the fishpond by encroaching on the fishpond walls. As part of recent restoration efforts by Paepae o Heʻeia, mangroves were removed from the fishpond and the fishpond wall; however, mangrove stands still grow along Kamehameha Highway (PBR Hawaiʻi 2007).

Figure 4-7. Heʻeia Stream Bank in Heʻeia State Park, Dominated by Invasive Mangroves (December 16, 2014)

Effect Types and Significance Criteria

Potential effects on wetlands would be considered significant if any net loss of wetland habitat occurred, or if modifications to wetland habitat adversely affected a wetland's hydrology and ability to support native flora and fauna. Hawai'i has lost nearly a third of its coastal wetlands to agricultural and urban development (Dahl 1990, Kosaka 1990). Further loss of coastal wetlands in He'eia would not only affect the local watershed but would reduce the ecological services provided by wetlands to humans and native flora and fauna on the island (Ducks Unlimited 2000, Rauzon and Drigot 2002). However, neither the proposed action nor the alternatives include modifications to wetlands.

The potential effect types in Table 4-2 below reflect the criteria described above for each of the four wetland types discussed in this section. The introduction and spread of invasive species also could contribute to the cumulative impacts on wetlands. Habitat-level effects of invasive species on wetlands would be considered significant if they further degraded the function of wetlands, for example, if greater incursions by mangroves caused additional impacts on wetland hydrology and chemistry.

4.1.3 Freshwater Stream Habitats

The main tributary in the proposed action area, He'eia Stream, is listed in the Hawai'i Stream Assessment (Parham et al. 2008) as a small perennial stream containing moderate aquatic resources. In ranking streams according to a suite of ecological diversity and resilience factors, Parham et al. (2008) assign streams a standardized score from 1 to 10, with 1 being the poorest and 10 being the best. He'eia Stream received a Stream Biological Rating of 4, and is noted to contain moderately important biological resources that include diverse native and introduced macrofauna (Townscape 2010). The stream goby (o'opu nakea, *Awaous guamensis*) was identified as occurring in the stream, as well as seven other native aquatic (fish) species and five introduced species (Townscape 2011a). Largest of the Hawaiian gobies, *A. guamensis* is the only one of the five species of o'opu that is not endemic to the Hawaiian Islands. This species is also found in Guam, New Caledonia, Vanuatu, and Fiji, and is considered indigenous in Hawai'i.

Table 4-2. Information Available for Analysis of Wetland Habitat Effects

Potential Effect	Type and Scale of Information Needed to Support Significance Determination	Existing Sources	Is Sufficient Information Available?		
			Proposed Action	Alt. 1: Boundary Expansion (Uplands, Entire HCDA Parcel)	Alt. 2: Boundary Expansion (Outer Reefs)
Net loss of wetland habitat due to conversion of wetland to upland and/or degradation of wetland quality due to cumulative effect of invasive species	Determination and delineation of wetland habitats	• USFWS 2015a: Source identifies the NWI wetland types. • USDA 2011: Source documents a systematic survey to identify and delineate wetlands in He‘eia.	Yes	Yes	Yes
	Details of ongoing and planned agricultural activities in wetlands	• Townscape 2011a and b: These sources do not discuss reclaiming wetland areas to convert to upland habitats among the various restoration activities that currently occur or are planned for the wetlands. • Brooks 1991: Source states that fishpond restoration does not entail conversion from wetland to upland habitat.	Yes	Yes	Yes
	Current distribution and abundance of invasive species	• Calvin Kim and Associates 1990, Townscape 2011a and b, PBR Hawai‘i 2007: These sources describe in detail the distribution of invasive plants and also discuss their impacts on the functioning of wetlands.	Yes	Yes	Yes
Effects on He‘eia Stream (freshwater emergent) habitat	Distribution and status of the wetland stream habitat	• Calvin Kim and Associates 1990, Townscape 2011a and b: These sources describe species composition in He‘eia Stream, distribution of native plants, and the extent of encroachment of invasive plants that impede streamflow. These sources also discuss stream restoration activities and conservation BMPs to prevent impacts on stream habitat and water quality.	Yes	Yes	Yes

Potential Effect	Type and Scale of Information Needed to Support Significance Determination	Existing Sources	Is Sufficient Information Available?		
			Proposed Action	Alt. 1: Boundary Expansion (Uplands, Entire HCDA Parcel)	Alt. 2: Boundary Expansion (Outer Reefs)
Effects on mangrove swamp (estuarine and marine) habitats	Distribution and status of the mangrove swamp habitat	• Brooks 1991, PBR Hawai‘i 1993, Townscape 2011a and 2011b: These sources describe distribution of mangrove swamp and impacts of mangroves on the biological, chemical, and physical characteristics of estuarine habitat in He‘eia; they prescribe restoration of mangroves to marsh habitat with native sedges and implementation of BMPs to avoid impacts on hoary bats inhabiting mangroves.	Yes	Yes	Yes
Effects on marsh and seasonally wet grassland (freshwater emergent) habitats	Distribution and status of the marsh habitats (floodplains of the He‘eia Stream)	• Calvin Kim and Associates, Townscape 2011b: These sources document distribution and composition of species found in the marsh and seasonally wet meadows. • PBR Hawai‘i 1993, Townscape 2011a and b: These sources describe invasion and degradation of marsh habitat by California grass and unsuitability for native waterbirds; they also prescribe restoration of marsh and seasonally wet grasslands to taro lo‘i and loko i‘a kalo, plus predator control program for rats, mongooses, cats, and dogs.	Yes	Yes	Yes
Effect on freshwater forested/shrub wetland	Distribution and status of freshwater forested/shrub wetland	• Townscape 2011a and b: These sources describe the distribution and composition of this wetland type.	Yes	Yes	Yes
Effect on freshwater pond wetland	Distribution and status of freshwater pond wetland	• Townscape 2011a and b: These sources describe the distribution and composition of freshwater ponds in He‘eia.	Yes	Yes	Yes

Notes: Alt = Alternative; BMPs = best management practices; HCDA = Hawai‘i Community Development Authority; NWI = National Wetlands Inventory; USDA = U.S. Department of Agriculture; USFWS = U.S. Fish and Wildlife Service.
Yes = Existing sources are sufficient for analysis.

In 2001–2003, the Hawai‘i Biological Survey examined the lower reaches and nearshore estuarine waters of He‘eia Stream and documented a total of six fish species: the endemic flagtail (āholehole, *Kuhlia xenura*) and flathead gray mullet (‘ama‘ama, *Mugil cephalus*); the indigenous great barracuda (ono, *Sphyraena barracuda*); and the introduced western mosquitofish (*Gambusia affinis*), shortfin molly (*Poecilia mexicana*), and tilapia (*Tilapia melanothera*) (Englund et al. 2003). Only two species of insects were documented by Englund et al. (2003), one of these being the indigenous dragonfly (*Pantala flavescens*). Parham et al. (2008) reported 15 fish species and the endangered blackline Hawaiian damselfly (*Megalagrion nigrohamatum nigrolineatum*) as occurring in He‘eia Stream, based on eight surveys conducted in the lower and middle sections of the stream between 1975 and 2003. Low aquatic insect diversity may be attributed to the high-salinity environment of lower He‘eia Stream.

Key threats to native and indigenous freshwater and estuarine fish and invertebrate species and their habitats include degradation resulting from the introduction of nonnative species (which prey on and displace native aquatic species and alter habitat), water diversion, stream channelization, pollution and sedimentation, and nonpoint sources of water pollution (Bishop Museum 2010, Townscape 2010).

Effect Types and Significance Criteria

Potential effects on freshwater stream habitats could result from construction activities or other disturbances, which may directly affect stream habitat by changing streamflow or stream gradient, or by altering other physical characteristics and thereby indirectly displacing fish, invertebrates, or aquatic insects. Land uses that cause substantial sedimentation or that alter natural stream channels could reduce the amount of habitat available for native species. Similarly, if invasive aquatic species are introduced via human activities, they could displace and greatly reduce the abundance of native species, especially those with specific and limited habitat requirements.

Potential effects on freshwater stream habitats would be considered significant if changes in the quantity or quality of stream habitats resulted in permanent or substantive declines in the number of native aquatic species or if He‘eia Stream receives a reduced Stream Biological Rating as a result of activities associated with the proposed action or Alternative 1.

Table 4-3. Information Available for Analysis of Freshwater Stream Habitat Effects

Potential Effect	Type and Scale of Information Needed to Support Significance Determination	Existing Sources	Is Sufficient Information Available?		
			Proposed Action	Alt. 1: Boundary Expansion (Uplands, Entire HCDA Parcel)	Alt. 2: Boundary Expansion (Outer Reefs)
Adverse effects on freshwater stream habitats and on native and endemic freshwater species	• Characterization of aquatic communities • Physical stream habitat variables • Early detection and management actions necessary to minimize and avoid invasive species introductions	Englund et al. 2003, Parham et al. 2008, and Townscape 2010: These sources document the types of habitat and biological communities that are present, and identify threats.	Yes	Yes	Yes

Notes: Alt = Alternative; HCDA = Hawai‘i Community Development Authority.
Yes = Existing sources are sufficient for analysis.

4.1.4 Estuarine Habitats

The upper intertidal parts of the proposed action area, including the seaward portion of He‘eia Fishpond and lower reaches of He‘eia Stream, are dominated by red mangrove and estuarine mudflats, and are inundated by fresh water from He‘eia Stream and by seawater when the tide is high (Figure 4-1). Large fluctuations in water quality in the estuary cause abrupt changes in dissolved oxygen, pH, salinity, and temperature (Jokiel 1991). The mangroves capture sediment and organic material that are transported downstream and deposited in the estuary, creating a silty mud bottom along the coast. These areas function as breeding and nursery habitat for marine life and attract many resident coastal species that are tolerant of changes in salinity. Currently, the estuarine ecosystem of He‘eia is vulnerable to effects resulting from polluted runoff, changes in land use patterns, accelerated or changed rates of freshwater discharge, fishpond modifications, wetland management, and construction associated with urbanization.

Following curtailment of sewage discharges in 1978–1979, researchers noted shifts and an apparent decline in the abundance and distribution in southern Kāne‘ohe Bay of the rare inarticulated brachiopod, *Lingula reevii*, a federal Species of Concern (Woo 2000, Hunter et al. 2008). These changes suggested that, after the diversion of sewage, *L. reevii* may have been affected by changes in sediment deposition rates and factors such as lower particulate organic food supply (Hunter et al. 2008). Adverse effects may have been exacerbated further by habitat alteration and displacement caused by the spread of the mat-forming invasive red algae, *Kappaphycus striatum* (Woo 2000, Hunter et al. 2008). Planned horizontal directional drilling during the implementation of the HIMB Infrastructure Rehabilitation and Replacement Project at Moku o Lo‘e has the potential to further alter the estuarine environment in this portion of the proposed action area, but impacts are expected to be short term (Community Planning and Engineering, Inc. 2014).

Effect Types and Significance Criteria

Although estuarine habitats and resources are vulnerable to a wide range of adverse effects resulting from human activities and natural events, they are not expected to be affected directly by the proposed action or alternatives. Effects that may be considered in the programmatic NEPA analysis may include potential increases in stormwater discharge, pollution, or construction runoff. These could threaten fish, invertebrates, or other organisms in the estuary. Also, if human activities contributed to the invasion of species such as marine algae, these could degrade estuarine habitats and displace native flora and fauna.

Effects on estuarine habitats and resources would be considered significant if activities associated with the proposed action caused the direct loss of habitat or mortality of fish and benthic communities, through sedimentation, reduction in water quality (as measured by total suspended solids [TSS], dissolved oxygen, and nutrient levels), polluted discharge, or invasive species. Prolonged exposure to these types of stressors would be significant if effects resulted in long-term or permanent declines in populations of key indicator species.

Table 4-4. Information Available for Analysis of Estuarine Habitat Effects

			Is Sufficient Information Available?		
Potential Effect	**Type and Scale of Information Needed to Support Significance Determination**	**Existing Sources**	**Proposed Action**	**Alt. 1: Boundary Expansion (Uplands, Entire HCDA Parcel)**	**Alt. 2: Boundary Expansion (Outer Reefs)**
Effects on estuarine habitats and resources	• Current estuarine processes and threats	Woo 2000, Englund et al. 2003, Hunter et al. 2008, and Townscape 2010: These sources document estuarine processes, biological responses to sedimentation, pollution, urbanization, and invasive species.	Yes	Yes	Yes

Notes: Alt = Alternative; HCDA = Hawai‘i Community Development Authority.
Yes = Existing sources are sufficient for analysis.

4.1.5 Coastal and Marine Habitats

The coastal waters of Kāne‘ohe Bay are influenced by a combination of estuarine and marine processes, and support a dynamic ecological structure composed of diverse assemblages of marine invertebrates, coral, and fish. The proposed action area is located between the southeastern and central sections of Kāne‘ohe Bay; the waters in this area are characterized by relatively high rates of freshwater input and slower overall rates of circulation.

Three distinct physiographic zones that define the marine environment of Kāne‘ohe Bay were described by Jokiel (1991)—inshore, inner bay, and outer bay. Most of the inshore area is fronted by shallow fringing reef <3.3 feet deep that extends 1640–2460 feet offshore. Seaward of this fringing reef and the intertidal

zone lie the inner bay and lagoon, which include patch reefs containing rich coral colonization, algal communities, and sand and sea grass beds. The inner bay waters support abundant planktonic organisms (Smith et al. 1981, Taguchi and Laws 1987, Ringuet and Mackenzie 2005) and a diverse assembly of reef-associated and pelagic fish species (Jokiel 1991, Hunter and Evans 1995). The inner bay receives considerably more oceanic enrichment than do the inshore waters because of its physiography relative to the open ocean. The outer bay is fronted by a barrier reef complex that slopes gently seaward and receives considerable marine nourishment, owing to wind-driven mixing of surface waters and transport of deeper oceanic waters into the bay.

In total, about 25% of the more than 6500 currently described species of Hawaiian coral reef organisms are endemic (Fautin et al. 2010), and many of these are found among the diverse habitats of Kāneʻohe Bay. Kāneʻohe Bay is considered an outstanding world-class scientific and field research setting because of the complex patch reef structure, fringing reef that extends the landward margin, well-flushed lagoon, and diversity of habitats and organisms present (Bahr et al. in prep.).

During storm events, coastal waters can receive a considerable influx of fresh water and particulate organic material, resulting in amplified sedimentation and reductions in salinity that acutely affect the health and stability of coral reef communities on short times scales. Discharges of polluted waters into Kāneʻohe Bay have occurred in the vicinity of the proposed action area; these can result in chronic mortality of coral and other organisms, which may take years to recover (Jokiel et al. 1993). Since the 1980s, coral bleaching events have been documented with increased frequency on a global scale, sometimes resulting in severe mortality of affected corals. The first large-scale coral bleaching event in Hawaiʻi occurred during the late summer of 1996 and was monitored closely in Kāneʻohe Bay (Jokiel and Brown 2004). A second major bleaching event occurred in the Northwestern Hawaiian Islands during summer 2002 (Brainard 2002, Aeby et al. 2003). Because bleaching events are occurring with greater frequency in response to ocean and atmospheric forces, resource management agencies and HIMB are closely monitoring the onset of these events and the recovery of corals in Kāneʻohe Bay (Jokiel and Brown 2004, Buddemeier et al. 2008).

Lastly, diseases that adversely affect the health and survival of corals have been documented in Kāneʻohe Bay. *Montipora* white syndrome (aMWS), a tissue-loss disease found on corals throughout the Hawaiian Archipelago, affects only *Montipora capitata* (rice coral), a common and widespread species in Kāneʻohe Bay. Research on the causes of the disease has identified the bacteria *Vibrio owensii* as a potential bacterial coral pathogen that affects Hawaiʻi's reefs (Ushijima et al. 2012). These types of stressors could contribute to cumulative effects on the ecological resilience of marine habitats in the proposed action area and the Alternative 2 outer reef boundary expansion area.

Effect Types and Significance Criteria

Because the proposed action and alternatives would mostly involve activities in the terrestrial environment, any potential effects of the NERR designation on coastal and marine habitats likely would stem from

fishpond management, wetland management, stream habitat modifications, and any activity that might contribute to changes in the rate and constituent properties of freshwater discharge. Specifically, potential adverse effects could be caused not only by unusually high rates of freshwater discharge, but by related introductions of nonnative invasive species and inputs of polluted runoff. Habitat effects could contribute to, or be exacerbated by, an increased incidence or severity of coral bleaching events or of diseases that affect corals and other organisms (Hunter and Evans 1995, Jokiel et al. 2004).

Effects on coastal and marine habitats and resources would be considered significant if they resulted in loss of available habitat for reef corals, other benthic organisms, or fish, through the introduction and proliferation of invasive marine algae or increased incidence of diseases that could adversely affect the resilience of the coastal and marine ecosystem in the proposed action and Alternative 2 areas. These significant effects would be predicted to occur if water quality were considered likely to worsen as a result of the action or alternatives, as measured by the standards set by the State (see Section 4.5, "Water Quality").

Table 4-5. Information Available for Analysis of Coastal and Marine Habitat Effects

			Is Sufficient Information Available?		
Potential Effect	**Type and Scale of Information Needed to Support Significance Determination**	**Existing Sources**	**Proposed Action**	**Alt. 1: Boundary Expansion (Uplands, Entire HCDA Parcel)**	**Alt. 2: Boundary Expansion (Outer Reefs)**
Effects on coastal and marine habitats and resources	• Distribution, health, and relative abundance of coral species • Occurrence, severity, and distribution of invasive species and diseases • Bleaching events and severity • Resource uses and sustainability	Jokiel et al. 1993, Hunter and Evans 1995, Woo 2000, Brainard 2002, Friedlander and DeMartini 2002, Aeby et al. 2003, Jokiel and Brown 2004, Ringuet and Mackenzie 2005, Fautin et al. 2010, Baker et al. 2011, Ushijima et al. 2012, Guidry et al. 2013, and Bahr et al. in prep.: These sources characterize the ecology of Kāneʻohe Bay and adjacent coastal marine systems, identify programs that detect invasive species and pathogens, and identify the existing resource management framework.	Yes	Yes	Yes

Notes: Alt = Alternative; HCDA = Hawaiʻi Community Development Authority.

Yes = Existing sources are sufficient for analysis.

4.2 Endangered and Threatened Species

4.2.1 Rare, Endangered, and Threatened Plants

More than 343 plant species are listed as threatened or endangered in the State of Hawai‘i. Critical habitat has been designated for a limited number of listed plant species or plant species clusters; however, the proposed action area does not overlap with any such critical habitat (USFWS 2015b). Given the long history of land disturbance in the action area, it is not surprising that the area's wetlands and uplands do not apparently harbor any rare, threatened, or endangered plants.

Krauss (1976) reported that the native plants pili (*Heteropogon contortus*), ‘ākia (*Wikstroemia* sp.), mountain nuapaka (*Scaevola gaudichaudii*), and ‘ōhi‘a lehua (*Metrosideros collina*) grow in the vicinity of the proposed action area, just east of Kahekili Highway and about 0.5 mile north of Haiku Road. Indigenous hala (*Pandanus tectorius*) and hau trees were observed in a residential neighborhood near the action area, just east of the He‘eia small boat harbor (Lamoureux 1986). Native plants reported in He‘eia State Park are hala, hau, loulu (*Pritchardia* sp.), and naupaka (*Scaevola sericea*) (Weissich 1993).

Although these surveys, conducted since the 1970s in and around the action area, reported some native plants, none except LeGrande (2006) reported the presence of threatened or endangered plant species (Krauss 1976, Lamoureux 1983, Calvin Kim and Associates 1990, Brooks 1991, Weissich 1993). *Achyranthes* (*A. splendens* var. *rotunda*) was the only endangered, endemic plant reported (LeGrande 2006); it is cultivated in the residential neighborhood near the fishpond. Although this variety of the species is both State- and federally listed as endangered (USFWS 2013), because the individuals found on the property had been planted and their provenance could not be determined, the plants do not have the same protection status that is given to wild plants (HAR Section 13-107-7).

Effect Types and Significance Criteria

Potential effects of the proposed action or alternatives on threatened and endangered plants would be considered significant if these plant species' populations or their habitats were adversely affected. An adverse effect on a population would entail a direct or indirect effect that caused the destruction of a rare, threatened, or endangered plant or its population. An adverse effect on the habitat of a rare, threatened, or endangered plant would entail alteration of the habitat such that it could no longer support the recruitment and establishment of these plants. No such effects are anticipated to occur, because these plants are apparently absent from the action and alternative areas.

Table 4-6. Information Available for Analysis of Effects on Rare, Endangered, and Threatened Plants

Potential Effect	Type and Scale of Information Needed to Support Significance Determination	Existing Sources	Is Sufficient Information Available?		
			Proposed Action	Alt. 1: Boundary Expansion (Uplands, Entire HCDA Parcel)	Alt. 2: Boundary Expansion (Outer Reefs)
Effects on threatened or endangered plant populations or habitats	Distribution of rare, threatened, or endangered plants in the action area	• Krauss 1976, Lamoureux 1983, PBR Hawai‘i 1993, LeGrande 2006, Townscape 2011a and b, USFWS 2013: These sources document that no threatened or endangered plants have been found around upland areas, in residential areas along Kamehameha Highway (except as noted), in He‘eia State Park, or in wetlands; the sources also discuss that the upland areas in particular are highly degraded by urbanization and unlikely to support rare, threatened, or endangered plants. • USFWS 2015b: This source documents that the action area is not designated or proposed as critical habitat for listed plants.	Yes	Yes	Yes

Notes: Alt = Alternative; HCDA = Hawai‘i Community Development Authority; USFWS = U.S. Fish and Wildlife Service.
Yes = Existing sources are sufficient for analysis.

4.2.2 Endangered and Threatened Terrestrial Wildlife

Like all areas in Hawai‘i that still have vegetative cover, the terrestrial habitats in the proposed action and alternative areas could support rare, candidate, threatened, or endangered species. In recent coordination letters regarding projects in the vicinity of He‘eia, USFWS listed the Hawaiian stilt (ae‘o, *Himantopus mexicanus knudseni*), Hawaiian moorhen, Hawaiian coot (‘alae kea, *Fulica alai*), Hawaiian duck (koloa maoli, *Anas wyvilliana*), and the Hawaiian hoary bat (‘ope‘ape‘a, *Lasiurus cinereus semotus*) as federally listed species that may occur in the He‘eia area (Townscape 2011b, Community Planning and Engineering, Inc. 2014). USFWS based this advice on data compiled by the Hawai‘i Biodiversity and Mapping Program and the Hawai‘i GAP Program, and on information from USFWS files.

Of the vegetated habitats in the proposed action area, the wetlands offer the greatest potential to support or attract special-status species. Biannual waterbird counts conducted at He‘eia marsh confirm that the site is used by all four endangered waterbirds listed above, albeit in low numbers (DOFAW unpublished data,

USFWS 2011). Recent biological surveys of wetlands in the proposed action area found only sporadic occurrences of listed avian species. A 2011 biological survey of the Kākoʻo ʻŌiwi wetlands recorded only a mallard-koloa hybrid (*Anas* sp.) in loʻi and open-water ponds (Townscape 2011a). In addition, workers at Kākoʻo ʻŌiwi observed a pair of stilts visiting and nesting in the wetland during the past 2 years (Shultz pers. comm. 2014).

Recent environmental assessments and conservation planning conducted for sites in the Heʻeia area include correspondence from USFWS that advises of the potential presence of the Hawaiian hoary bat, another terrestrial listed species (Townscape 2011b, Community Planning and Engineering, Inc. 2014). Field surveys for these projects focused on birds and incidental observations of introduced mammals; no surveys were conducted specifically for Hawaiian hoary bats, although their potential presence was acknowledged (Helber Hastert & Fee 2007, Community Planning and Engineering, Inc. 2014). Helber Hastert & Fee (2007) noted that the Hawaiian hoary bat is known to forage over ponds and bays and roost in dense forests similar to the hau and mangrove vegetation in the proposed action area.

Townscape (2011a) further identified the Hawaiian owl (pueo, *Asio flammeus sandwichensis*) and Oʻahu creeper (ʻaluahio, *Paroreomyza maculata*) as listed species with potential to occur in the proposed action area, but this information was likely based on historical or regional records. These species were not included in USFWS coordination letters for projects in the vicinity, have not been recorded during recent surveys, and are not mentioned in other environmental assessments from the area. The last well-documented observation of Oʻahu creeper was of two birds seen on Poamoho Trail (west of the ahupuaʻa of Heʻeia—on the west facing slopes of the Koolau Range) in 1985 (USFWS 2006).

None of the terrestrial habitats that occur in the action or alternative areas are identified as proposed or listed critical habitat for any endangered species (Helber Hastert & Fee 2007, Townscape 2011a, Community Planning and Engineering, Inc. 2014, USFWS 2015b). Critical habitat has not been designated for any of the listed waterbird species, and the Heʻeia marsh was not identified as one of the "core" wetlands in the most recent recovery plan for endangered Hawaiian waterbirds (USFWS 2011). However, Heʻeia marsh was identified as a "supporting" wetland. The USFWS recovery plan describes Heʻeia as a site that historically had value as a complex of tidal marshes and open-water areas, but which has been substantially modified and presently consists of nonnative mangroves, remnants of ponds, and wet pasture. The recovery plan recommends that Heʻeia be restored and managed by the State to provide enhanced habitat for endangered waterbirds (USFWS 2011).

Conservation management actions recommended for the Heʻeia wetlands in the USFWS endangered waterbird recovery plan include actions to combat the impacts of invasive species, such as managing vegetation, controlling undesirable plant species, preventing introduction of invasive nonnative plants, eliminating predators, controlling avian disease, and removing the threat of mallard-koloa hybridization (USFWS 2011). Invasive species are recognized as a major problem in the Heʻeia wetlands by the

conservation plans developed by Kākoʻo ʻŌiwi for its wetland conservation project (Townscape 2011a, 2011b). The proposed action and alternatives are consistent with the recovery plan recommendations.

Effect Types and Significance Criteria

Effects on listed waterbirds would be considered significant if *take*[1] occurred, or if occupied habitat were significantly degraded or made unsuitable. One circumstance in which such effects could occur is if current or future management of wetlands attracted listed waterbirds, and then the wetlands were left unmanaged or were poorly managed. Such a change could result in failed nesting attempts and adult mortality, and consequent declines of waterbird populations. Management of occupied wetlands must minimize losses by predators (rats, mongooses, cats, and dogs), losses to avian disease (botulism), and hunting by humans (USFWS coordination letter in Townscape 2011b). The introduction and spread of nonnative invasive species also has been identified as contributing to cumulative impacts on threatened and endangered species and other trust resources in the Heʻeia area; population-level effects of invasive species on listed waterbirds and their habitat may be considered significant if the invasive species caused mortality (e.g., via the introduction of a pathogen or predator) of listed species or degraded their habitat (e.g., via a weed invasion) to such a degree as to cause a population decline.

Effects on the Hawaiian hoary bat would be considered significant if young bats were at risk of being harmed or killed when left unattended in woody vegetation (USFWS coordination letter, in Townscape 2011b). Also, as described for waterbirds, the introduction and spread of nonnative invasive species could be considered a significant effect on the hoary bat if the invasive species caused mortality (e.g., via the introduction of a pathogen or predator) of bats or degraded their habitat (e.g., via a tangling weed invasion) to such a degree as to cause a population decline.

4.2.3 Endangered and Threatened Marine Species

The ecosystem in Kāneʻohe Bay contains a diverse array of marine and freshwater habitats that may support several State- or federally listed threatened, endangered, and special-status species. Coral reefs are recognized as Essential Fish Habitat (EFH) under the provisions of the Magnuson-Stevens Fishery Conservation and Management Act (50 CFR 600) and are managed by the National Marine Fisheries Service (NMFS) to ensure the conservation and enhancement of EFH. In October 2009, the Center for Biological Diversity petitioned NMFS to list 83 reef-building corals as threatened or endangered under the Endangered Species Act (ESA) and to designate critical habitat. Seventy-five of the petitioned species occur widely in the Indo-Pacific region. NMFS conducted an extensive review and determined that 40 of the Indo-Pacific species in the proposal did not warrant listing, including several coral species that had already been listed as threatened and which occur in Hawaiʻi (NOAA 2014). As a consequence of the

[1] The term *take* means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct (Title 16, United States Code [USC], Section 1532).

Table 4-7. Information Available for Analysis of Effects on Endangered and Threatened Terrestrial Wildlife

Potential Effect	Type and Scale of Information Needed to Support Significance Determination	Existing Sources	Is Sufficient Information Available?		
			Proposed Action	Alt. 1: Boundary Expansion (Uplands, Entire HCDA Parcel)	Alt. 2: Boundary Expansion (Outer Reefs)
Direct or indirect take of listed birds or their habitat	• Current rare bird distribution and abundance	PBR Hawai‘i 1993, Helber Hastert & Fee 2007, Townscape 2011a and b, USFWS 2011, Community Planning and Engineering, Inc. 2014: All sources except USFWS 2011 and Townscape 2011a document that no listed species or habitat are found in the action area; USFWS 2011 and Townscape 2011a note presence of small numbers of listed endangered waterbirds in the Kākoʻo ʻŌiwi wetland habitat: koloa, mallard-koloa hybrid, and Hawaiian stilt, coot, and moorhen.	Yes	Yes	Yes
Effects of invasive species on listed birds or their habitat	• Current distribution and abundance of invasive species	USFWS 2011 and Townscape 2011a: These sources document the presence of and problems with invasive species in the Kākoʻo ʻŌiwi wetland habitat. They also identify conservation measures to control invasive species.	Yes	Yes	Yes
Direct or indirect take of listed mammals or their habitat	• Current distribution and abundance of Hawaiian hoary bat in the action and alternatives areas	Townscape 2011a and b, Community Planning and Engineering, Inc. 2014: These sources acknowledge the potential presence of Hawaiian hoary bats and identify measures to avoid take.	Yes	Yes	Yes
Effects of invasive species on listed mammals or their habitat	• Current distribution and abundance of invasive species	Townscape 2011a and b, Community Planning and Engineering, Inc. 2014: These sources document the presence of and problems with invasive species, and identified measures to avoid take. Also see Table 4.1 for information needed regarding invasive species.	Yes	Yes	Yes

Notes: Alt = Alternative; HCDA = Hawai‘i Community Development Authority; USFWS = U.S. Fish and Wildlife.
Yes= Existing sources are sufficient for analysis.

NMFS ruling, there are presently no federally listed species of coral in the Hawaiian Islands. Effects on sensitive coral species are not discussed further in this section, but coral bleaching, coral resilience, and acidification of the ocean are discussed in Section 4.1.5, “Coastal and Marine Habitats,” Section 4.3.4, “Marine Fauna,” and Section 4.7, “Climate.”

Two federally listed marine vertebrates are known to occur near the proposed action and Alternative 2 areas: the threatened green sea turtle (honu, *Chelonia mydas*) and the endangered Hawaiian monk seal (*Monachus schauinslandi*).

The green sea turtle forages and rests in Kāneʻohe Bay. As elsewhere in the main Hawaiian Islands, green turtles in Kāneʻohe Bay were legally hunted until 1978, when full protection was provided under the ESA. The species has exhibited a consistent increase in the number of nesting females over the past 4 decades, suggesting that the population may be increasing at a steady rate (Hamburg and Balazs 2014). In March 2014, NMFS and USFWS published a proposed rule that would classify the Hawaiian green turtle population as a Distinct Population Segment (referred to in the proposed rule as the Central North Pacific DPS), and that delisting this DPS currently is not warranted (USFWS and NOAA 2015).

Balazs et al. (1998) reported that, between 1989 and 1998, of 581 turtles captured, examined, and tagged in Kāneʻohe Bay, 43.9% exhibited manifestations of the tumor-forming disease fibropapillomatosis (FP). The causes of FP are not clear, but research is being conducted to gain insight into whether habitat or related environmental factors might affect the distribution and prevalence of FP. Kāneʻohe Bay and adjacent coastal waters constitute important, long-term, in-water research sites that have been established in the main Hawaiian Islands to monitor FP prevalence and obtain baseline data on the biology, ecology, behavior, and life history of green turtles (Balazs et al. 1998, Francke et al. 2013).

The Hawaiian monk seal also may occur in the marine habitat of the proposed action and Alternative 2 areas. Although the seal has experienced a significant population decline in the last few decades and most of the current population resides in the Northwestern Hawaiian Islands, an increasing number of sightings and births have recently occurred in the main Hawaiian Islands. The 2011 best minimum abundance estimate for the main Hawaiian Islands is more than 150 seals, and it appears that the population is continuing to expand. Monk seals in the main islands forage, travel, and rest in nearshore waters, increasingly close to human population centers, including popular beaches, marinas, streams, coastal lagoons, and estuaries. In these areas, the seals may be exposed to agricultural activity, livestock, feral and domestic animals, and sources of polluted runoff and sewage, which may increase disease transmission (Littnan et al. 2006, Aguirre et al. 2007).

Effect Types and Significance Criteria

Effects on marine mammals and reptiles would be considered significant if they involved direct or indirect take of individuals or degradation of the species' habitat such that the habitat became unsuitable for use by the animals. Construction and disturbance activities may temporarily displace Hawaiian monk seals and green turtles, but because of the habits of these species, they are not expected to be affected by activities associated with the proposed action or alternatives.

Table 4-8. Information Available for Analysis of Effects on Endangered and Threatened Marine Animals

Potential Effect	Type and Scale of Information Needed to Support Significance Determination	Existing Sources	Is Sufficient Information Available?		
			Proposed Action	Alt. 1: Boundary Expansion (Uplands, Entire HCDA Parcel)	Alt. 2: Boundary Expansion (Outer Reefs)
Direct or indirect take of listed marine mammals or their habitat	Distribution and status of Hawaiian monk seals in Kāneʻohe Bay	Goodman-Lowe 1998, Parrish 2004, Littnan et al. 2006, Aguirre et al. 2007, and Baker et al. 2011: The sources document ongoing efforts to evaluate the population structure of Hawaiian monk seals in the main Hawaiian Islands and evaluate environmental constraints, risks, and interaction with human activities.	Yes	Yes	Yes
Direct or indirect take of listed marine reptiles or their habitat	Distribution and status of green sea turtles in Kāneʻohe Bay	Balazs et al. 1998, Francke et al. 2013: These sources state that NMFS continues to assess the health and stability of green turtles in Kāneʻohe Bay, with an emphasis on assessing quality foraging resources, disease occurrence and prevalence, and outreach efforts designed to minimize risk and avoid take.	Yes	Yes	Yes

Notes: Alt = Alternative; HCDA = Hawaiʻi Community Development Authority; NMFS = National Marine Fisheries Service.
Yes = Existing sources are sufficient for analysis.

4.3 Other Flora and Fauna

4.3.1 Other Flora

A few native plant species, including some endemics, were recorded in past or recent surveys in the proposed action and Alternative 1 areas. This section describes the vegetation that occurs in each portion of the proposed action and Alternative 1 areas.

The vegetation in the northern half of the HCDA upland areas primarily comprises nonnative species. Introduced trees such as Christmas berry (*Schinus terebenthifolius*), Java plum (*Syzygium cumini*), silver oak (*Grevillea robusta*), strawberry guava (waiawī, *Psidium guajava*), and ironwood (paina, *Casuarina equisetifolia*) dominate the upland areas. Native shrubs akia and mountain naupaka, and the native pili grass, were reported to dominate the understory in the 1970s (Krauss 1976), but later surveys (Lamoureux 1983, Townscape 2011a) in and around these areas did not report an abundance of these species.

The vegetation in the southern half of the HCDA upland areas (which are scattered in and around the wetlands) may be intermittently flooded, but these areas largely do not support obligate wetland plants. One

endemic species, akia, and two indigenous species, hala and hau, were reported to occur along Kealohi Road (Townscape 2011a). Widespread introduced species reported include Java plum, maile pilau (*Paederia foetida*), basket grass (*Oplismenus hirtelius*), and wedelia (*Sphagneticola trilobata*).

The upland areas directly around the residential neighborhood support escaped ornamental plants such as yellow ginger (ʻawapuhi melemele, *Hedychium flavescens*), impatiens (*Impaitens sultani*), heliconia (*Heliconia* sp.), primrose willow (kāmole, *Ludwigia octivalvis*), and mango (*Magifera indica*). It is likely that the ground there remains moist year-round because obligate plant species such as taro (kalo, *Colocasia esculenta*), Chinese taro (*Alocasia cucullata*), and honohono (*Commelina diffusa*) also are reported to occur in this area (Calvin Kim and Associates 1990).

Herbaceous plants reported to be growing along Heʻeia Stream include basket grass, wedelia, and sword fern (lauaʻe haole, *Microsorium scolopendria*). Trees overhanging the stream include hau, rose apple (*Eugenia jambosa*), guava, macranga (*Macaranga grandifolia*), and octopus trees (Calvin Kim and Associates 1990). The understory vegetation lining the streambank includes species like Job's tears (kūkaekōlea, *Coix lachrymal-jobi*), wedelia, basket grass, dumb cane (*Dieffenbachia* sp.), ʻape (*Xanthosoma robustum*), banana, and umbrella sedge (ʻahuʻawa haole, *Cyperus alternifolius*).

Common facultative wetland plant species in the grasslands include California grass, honohono, sensitive plant (pua hilahila, *Mimosa pudica*), sedge (*Frimbristylis littoralis*), and Job's tears. Some parts of the seasonally wet grasslands have more natural marsh characteristics where the flow from Heʻeia Stream is diverted into channels and low-lying areas. Such areas support wetland obligate plant species such as arrowhead (*Sagittaria sagittaefolia*) and kāmole. Indigenous wetland plant species identified included ʻakaʻakai (*Schoenoplectus tabernaemontani*) and neke fern.

The vegetation along Kamehameha Highway, around the houses, mostly comprises cultivated plants such as mango, bananas, papaya (*Carica papaya*), ginger, crotons (*Croton* spp.), ti (ki, *Cordyline* spp.), and heliconias (*Heliconia* spp.). Avenue tree species such as monkey pod (*Samanea saman*) and false kamani (*Terminalia catappa*) are common. In some mauka (inland) gulches, guava, Christmas berry, Java plum, and ironwood form small patches of closed forest. The grasslands are dominated by introduced grasses such as broomsedge (*Andropogon virginicus*), California grass, molasses grass (*Melinis minutiflora*), guinea grass (*Megathyrsus maximus*), and dallis grass (*Paspalum dilatatum*), along with other introduced herbaceous plants such as vervain (*Stachytarpheta cayennensis*), partridge pea (laukī, *Chamaecrista nictitans*), and Spanish clover (kaʻimi, *Desmodium incanum*) (Lamoureux 1983).

A flora survey of Heʻeia State Park found a wide variety of ornamental and cultivated plant species, such as star fruit (*Averrhoa carambola*), bauhinia (*Bauhinia purpurea*), mango, and allspice (*Pimenta dioica*). Some indigenous plant species such as loulu, hala, milo (*Thespesia populnea*), and kukui (*Aleurites moluccana*) were also recorded to occur in the park.

The flora in and around the residential area to the east of the fishpond comprises ornamental plants, hau, and mangrove species of *Bruguiera sexangula*, *B. gymorhiza*, and red mangrove (Brooks 1991, LeGrande 2006). Several native plants have been recorded to be intentionally planted and cared for in this area. These include kalo (*Colocasia esculenta*), ʻahuʻawa (*Cyperus javanicus*), naupaka, naio (*Myoporum sandwicense*), ʻaʻaliʻi (*Dodonaea viscosa*), and pōhinahina (*Vitex rotundifolia*). As discussed in Section 4.2, the endangered *Achyranthes splendens* var. *rotunda* was found cultivated in the residential neighborhood. This variety is both State- and federally listed as endangered, but because the individuals found on the property were planted and their provenance could not be determined, the plants are not given the same protection status that wild plants receive.

The vegetation in the upland areas of Moku o Loʻe is highly disturbed by previous and ongoing land uses. The flora on the island predominantly comprises nonnative plants and only three indigenous plant species—naupaka, hau, and milo—were reported to occur on the island (Char & Associates 1994, 1995; SWCA 2013). Red mangrove and pickleweed (*Batis maritima*) are common along the shoreline. Coconut (*Cocus nucifera*), phoenix palms (*Phoenix* sp.), ironwood, milo, and red powderpuff (*Calliandra haematocephala*) are some of the commonly seen trees on the island. Ornamental and cultivated plants growing on the island include Bermuda grass (*Cynodon dactylon*), red ginger (*Alpinia purpurata*), plumeria (*Plumaria pudica*), papaya, and ixora (*Ixora* sp.). Other common nonnative and weedy plants recorded on the island included Christmas berry, octopus tree, koa haole, pitted beardgrass (*Bothriochloa pertusa*), Hilo grass (*Paspalum conjugatum*), Chinese violet (*Asystasia gangetica*), Indian fleabane (*Pluchea indica*), and spurges (*Euphorbia* spp.) (SWCA 2013).

Effect Types and Significance Criteria

Effects on the native plant species in the proposed action and alternative areas would be considered significant if they resulted in an overall reduction in population size or involved impacts on large numbers of individuals. Effects on native plants also would be considered significant if modification to their existing habitat prevented their recruitment and establishment. Impacts on habitats commonly result from land clearing or construction activities associated with development; however, no such activities are planned as part of the proposed action or alternatives. Rather, habitat modification through ongoing restoration projects is likely to have a positive effect on native plants.

Table 4-9. Information Available for Analysis of Effects on Other Flora

Potential Effect	Type and Scale of Information Needed to Support Significance Determination	Existing Sources	Is Sufficient Information Available?		
			Proposed Action	Alt. 1: Boundary Expansion (Uplands, Entire HCDA Parcel)	Alt. 2: Boundary Expansion (Outer Reefs)
Population-level effects on native flora or significant modification of habitat	Native species distribution and abundance, and evidence of modification of habitats	Krauss 1976, Lamoureux 1983, Calvin Kim and Associates 1990, Brooks 1991, PBR Hawai‘i 1993, LeGrande 2006, Townscape 2011a and b, and SWCA 2013: The sources provide a sufficient inventory of botanical resources, including the distribution and abundance of native plants. These sources also discuss ongoing and future habitat modifications, such as restoration projects.	Yes	Yes	Yes

Notes: Alt = Alternative; HCDA = Hawai‘i Community Development Authority.
Yes = Existing sources are sufficient for analysis.

4.3.2 Other Terrestrial Fauna

A variety of biological surveys and assessments have been done for projects in the He‘eia area in recent years (Helber Hastert & Fee 2007, Townscape 2011a, Community Planning and Engineering, Inc. 2014). The fauna found in the proposed action and Alternative 1 areas includes the common coastal, rural, and urban-introduced birds and mammals typically found in beachside, garden, parkland, and agricultural areas on O‘ahu, plus a few of the common wetland and coastal native and migratory species. This section describes the fauna that occurs in each portion of the proposed action and Alternative 1 areas.

Fauna identified in the wetland habitats includes cane toad (*Bufo marinus*); globe skimmer dragonfly (*Pantala flavescens*), scarlet skimmer (*Crocothemis servilia*), and three other dragonfly species (red, blue-green, and purple *Ischnura* spp.) near shallow stagnant water; a *Heteropoda* sp. cane spider (*Heteropoda venatoria*); cyclid fish, mosquitofish, and crayfish in the demonstration lo‘i and ponds; and mallard-koloa hybrid, Shama thrush (*Copsychus malabaricus*), and Pacific golden plover (kolea, *Pluvialis fulva*) (Townscape 2011a). Domestic ducks, black-crowned night herons (‘auku‘u, *Nycticorax nycticorax*), and cattle egrets (*Bubulcus ibis*) also have been recorded in waterbird surveys at the site (DOFAW unpublished data). Biannual waterbird counts conducted at He‘eia marsh confirm that the site is used by all four endangered waterbirds, albeit in low numbers (see Section 4.2.2, “Endangered and Threatened Terrestrial Wildlife”). Bullfrogs (*Rana catesbiana*) have been observed in small ponds in the seasonally wet grasslands (Calvin Kim and Associates 1990).

A survey for avifauna and feral mammals near the fishpond identified common native and nonnative birds and introduced mammals typically found in this region and throughout Oʻahu, including nine alien species of birds and one feral cat (*Felis catus*) (Helber Hastert & Fee 2007). Other mammals common to suburban areas, such as rats (*Rattus* sp.) and the house mouse (*Mus musculus*), are also likely to occur in the area. Native waterbirds such as black-crowned night herons and Hawaiian stilts have been reported along the edges of the fishpond. Although no native seabirds were recorded during the 2007 field survey, the black noddy (*Anous minutus*) and great frigatebird (ʻiwa, *Fregata minor*) are expected to occur in this region. The Pacific golden plover was reported using the limited lawn habitat at the site (Helber Hastert & Fee 2007).

A recent survey at Moku o Loʻe (Community Planning and Engineering, Inc. 2014) documented the common myna (piakelo, *Acridotheres tristis*), mallard-koloa hybrid, northern cardinal (*Cardinalis cardinalis*), common waxbill (*Estrilda astrild*), great frigatebird, zebra dove (*Geopelia striata*), red-crested cardinal (*Paroaria coronata*), Pacific golden plover, red-vented bulbul (*Pycnonotus cafer*), spotted dove (ekaho, *Streptopelia chinensis*), wandering tattler (ʻulili, *Tringa incana*), and Japanese white-eye (*Zosterops japonicas*). Approximately 30 individual native great frigatebirds were observed soaring above the island. Additionally, several individual ducks, likely to be mallard-koloa hybrids, were observed swimming in nearshore waters. Although not observed, black noddies are known to forage in Kāneʻohe Bay, and could occasionally forage in the nearshore waters of Moku o Loʻe. Mammals that are expected on the island include rats and mice. Lastly, the introduced monarch butterfly (*Danaus plexippus*) and the introduced honeybee (*Apis mellifera*) have been documented on the island (Community Planning and Engineering, Inc. 2014).

Migratory shorebirds are found in the proposed action area and will use the coastal habitats, estuaries, marshes, wetlands, and grasslands in the area. The *Pacific Islands Shorebird Conservation Plan* (Engilis and Naughton 2004) identifies Kāneʻohe Bay as an important tidal flat used by flocks of shorebirds that forage at low tides. The plan also identifies tidal flats, where mangroves have been effectively removed, as providing positive benefits to shorebirds. Most of the freshwater, ephemeral, and managed wetlands on the windward and north shores of Oʻahu, including Heʻeia marsh, are protected but exist in a degraded state. Lastly, the limited lawn habitat in the proposed action area could be used by the Pacific golden plover (Helber Hastert & Fee 2007).

Effect Types and Significance Criteria

Any effects on terrestrial fauna would be considered significant if large numbers of individuals or large portions of habitat were affected, such that the population of a species suffered a permanent decline. However, few effects on other terrestrial fauna are expected to result from the proposed action or alternatives. Any construction and other disturbance activities may temporarily displace species such as wandering tattler and Pacific golden plover if the activities are conducted during the migratory season, but these birds likely would return when construction is complete, and no long-term impacts are expected. Similarly, black noddies may be temporarily displaced during the rehabilitation of the Lighthouse Pier on

Moku o Loʻe, but the displacement is expected to be temporary. Great frigatebirds typically fly at high altitudes and are not expected to be affected by the proposed action or alternatives (Community Planning and Engineering, Inc. 2014).

Table 4-10. Information Available for Analysis of Effects on Other Terrestrial Fauna

			Is Sufficient Information Available?		
Potential Effect	**Type and Scale of Information Needed to Support Significance Determination**	**Existing Sources**	**Proposed Action**	**Alt. 1: Boundary Expansion (Uplands, Entire HCDA Parcel)**	**Alt. 2: Boundary Expansion (Outer Reefs)**
Population-level effects on other terrestrial fauna, or significant modification of habitat	Inventories of fauna in the action and alternatives areas	Helber Hastert & Fee 2007, Townscape 2011a, Community Planning and Engineering, Inc. 2014: These sources provide inventories of common native and introduced birds and mammals, as well as mitigation measures.	Yes	Yes	n/a

Notes: Alt = Alternative; HCDA = Hawaiʻi Community Development Authority.
Yes = Existing sources are sufficient for analysis.

4.3.3 Other Freshwater and Estuarine Fauna

Heʻeia Fishpond is the largest inland body of water in the proposed action area. This 88-acre seashore pond is located on the shoreline of Kāneʻohe Bay and is completely surrounded by a rock wall. The waters of the pond receive freshwater input from the Heʻeia Stream, which drains the Heʻeia watershed and empties into the northwestern corner of the fishpond. The fishpond retains a brackish character owing to a tidal influx of seawater from the adjacent Kāneʻohe Bay. Water flux into and out of the fishpond is regulated by a series of eight sluices. The pond has been used primarily as a site to promote aquaculture using traditional cultural practices of resource management (Helber Hastert & Fee 2007).

Fish species that live in the Heʻeia Fishpond and adjacent fresh and estuarine waters include Hawaiian ladyfish (ʻamaʼama, *Elops hawaiensis*), milkfish (awa, *Chanos chanos*), Dussumierʼs surgeonfish (palani, *Acanthurus dussumieri*), flagtail (āholehole, *Kuhlia* spp.), threadfin (moi, *Polydactylus sexfilis*), porcupinefish (kokala, *Diodontidae*), barracuda (kākū, *Barracuda barracuda*), and juvenile trevally (papio, *Carangidae*). The waters of the fishpond also contain various species of brackish water shrimp (ʻōpae, *Atyidae*), moray eel (puhi, *Gymnothorax* spp.), and mollusks (Townscape 2010, Paepae o Heʻeia 2013).

Effect Types and Significance Criteria

The proposed action and alternatives are not expected to have direct or indirect effects on freshwater or estuarine fauna. Direct effects would be considered significant if they caused mortality of native freshwater organisms or long-term alteration of habitat necessary to support endemic species. Indirect effects would

be considered significant if they resulted in the inability of native freshwater species to reproduce normally or become established in unoccupied and otherwise suitable habitat. The introduction and spread of invasive species also would be considered to pose a significant threat to freshwater species and their habitats.

Table 4-11. Information Available for Analysis of Effects on Other Freshwater and Estuarine Fauna

			Is Sufficient Information Available?		
Potential Effect	**Type and Scale of Information Needed to Support Significance Determination**	**Existing Sources**	**Proposed Action**	**Alt. 1: Boundary Expansion (Uplands, Entire HCDA Parcel)**	**Alt. 2: Boundary Expansion (Outer Reefs)**
Effects on other freshwater and estuarine species	Species composition and habitat use	Helber Hastert & Fee 2007, Englund et al. 2003, Paepae o He'eia 2013: As part of the Final EA for He'eia Aquaculture Support Facilities, freshwater resources were identified in the action area. The sources also characterize threats and identify important species. Community-based conservation organizations have started to gather data on freshwater fish and invertebrates, as part of fishpond restoration.	Yes	Yes	Yes

Notes: Alt = Alternative; EA = environmental assessment; HCDA = Hawai'i Community Development Authority.
Yes = Existing sources are sufficient for analysis.

4.3.4 Other Marine Fauna

Most of the 40 known species of corals that are documented in Hawai'i occur in Kāne'ohe Bay, although only a few are abundant (Jokiel 1991). Hawai'i's corals are adapted to a wide range of wave energy conditions, which enables certain species to become widespread. The most abundant coral in Kāne'ohe Bay is the finger coral, *Porites compressa*, representing more than 75% of the total coral population in Kāne'ohe Bay (Maragos 1977, Jokiel 1991). Other common and fairly widespread species of coral found in Kāne'ohe Bay are *Montipora verrucosa*, *Pocillopora damicornis*, *Cyphastrea ocellina*, *Pavona varians*, and *Fungia scutaria*.

Besides corals, a wide range of other invertebrates occupy the soft- and hard-bottomed demersal habitats of Kāne'ohe Bay, such as various species of lobsters, crabs, octopus, pearl oysters, cowrie, cone shells, tunicates, sponges, shrimp, and feather duster worms (Jokiel 1991).

Kāne'ohe Bay is a recognized pupping ground for the scalloped hammerhead shark (manō kihikihi, *Sphyrna lewini*), which is considered the most abundant carnivore in the bay. Several other species of elasmobranch fishes reside in the waters of Kāne'ohe Bay, including the whitetip reef shark (*Trianodon obesus*), tiger shark (niuhi, *Galeocerdo cuvieri*), and a variety of rays (*Myliobatidae, Dasyiatidae*) (Jokiel 1991).

The marine waters of Kāneʻohe Bay in the proposed action and Alternative 2 areas support active recreational and subsistence fishing, and to a lesser extent, commercial fisheries. The fishery uses are broken down in general terms into those using active gear (hooks and lines, spears, trolls, crab nets, and throw nets) and those using passive gear (gill nets, surround nets, and traps). The main species taken using active gear are octopus, trevally and jacks (Carangidae), crabs (mainly *Portunus sanguinolentus*), goatfish (*Mullidae*), sharks (mainly scalloped hammerheads), akule (*Selar crumenophthalmus*), ʻawaʻawa (ladyfish, *Elops* spp.), uhu (*Scaridae*), taʻape (*Lutjanus kasmira*), and awa (milkfish, *Chanos chanos*). Octopus have consistently represented more than 50% of the total harvest of marine organisms taken for recreational and commercial uses, by all gear types and methods combined (Everson 1994, Everson and Friedlander unpublished data).

Over the years, considerable environmental and socioeconomic changes have affected the use of marine resources in Kāneʻohe Bay. Many of these changes have resulted in the introduction of regulatory measures that limit the catch and restrict the harvest season so as to support the replenishment and sustainability of resources. These regulatory measures are expected to continue, and may be adapted as new information becomes available and as threats and responses to various stressors are identified.

Effect Types and Significance Criteria

Threats to marine resources include overfishing, alteration of habitat, and displacement of fauna by the introduction and spread of invasive species, pollution, and disease. Any additional effects on other marine fauna would be considered significant if they resulted in the loss or significant decline of fish populations or coral species diversity, or in poor recovery of species. However, adverse effects on marine resources are currently minimized through public education, regulations, and enforcement, and further significant effects are not anticipated to result from the proposed action or alternatives.

Table 4-12. Information Available for Analysis of Effects on Other Marine Fauna

			Is Sufficient Information Available?		
Potential Effect	**Type and Scale of Information Needed to Support Significance Determination**	**Existing Sources**	**Proposed Action**	**Alt. 1: Boundary Expansion (Uplands, Entire HCDA Parcel)**	**Alt. 2: Boundary Expansion (Outer Reefs)**
Effects on other marine species	• Distribution and abundance of key species • Annual fishery data, including catch rates and statistics for recreation, subsistence use, and commercial fishing activity	Williams et al. 2008, Gombos et al. 2010: These sources provide data on recreational fishing effort and catch rates in the main Hawaiian Islands, and on biological/ecological resilience factors by region.	Yes	Yes	Yes

Notes: Alt = Alternative; HCDA = Hawaiʻi Community Development Authority.

Yes = Existing sources are sufficient for analysis.

4.4 Watershed and Hydrology

The action area is located in the 3.6-square-mile Heʻeia drainage basin, which extends 3.2 miles from the ocean to the 2826-foot summit of the Koʻolau Mountains (Townscape 2011a). In the basin, Haʻikū Stream and ʻIolekaʻa Stream merge to form the perennial Heʻeia Stream, which runs through the proposed action area. The terrestrial portion of the action area also includes approximately 405 acres of low-lying wetlands, most of which are within a floodway and within the Federal Emergency Management Agency's AE (high-risk) flood zone (Townscape 2011a). Another major water feature of the area is the Heʻeia Fishpond, an 88-acre brackish-water pond that extends from the shoreline out into Kāneʻohe Bay, enclosed by a 3500-foot-long wall built from volcanic rock and coral. A large storm damaged a 1000-foot portion of the wall in 1965, and the wall is slated for repairs in 2015 (U.S. Army Corps of Engineers 2012, Paepae o Heʻeia 2013). Lastly, the watershed is characterized by Kāneʻohe Bay. The bay is semienclosed by a barrier reef and therefore is heavily influenced by freshwater inputs. Heʻeia Stream is a relatively minor source of these inputs, given that it is only one of 11 streams that supply the bay with fresh water (Bahr et al. in prep.). Kāneʻohe Stream, just south of the proposed action area, is the largest freshwater source, accounting for more than 75% of the discharge into the southern section of the bay (Drupp et al. 2011).

Groundwater resources in the proposed action area were described in Kākoʻo ʻŌiwi (2011):

> The aquifer beneath the proposed site is within the Koʻolau Poko Aquifer System of the Windward Aquifer Sector. This aquifer mainly consists of high level dike-impounded groundwater. There are many groundwater seeps and springs in the wetlands of Heʻeia. The property area is located on the ocean side of the DOH Underground Injection Control (UIC) Line. There are no groundwater wells located onsite or in the vicinity of the property. The nearest groundwater wells are located in Upper Haʻikū Valley, on the mountainside end of Heʻeia watershed. These wells are not listed as having contaminants.

Heʻeia watershed quality is considered "impacted" owing to the amount of impervious surfaces (18.41%), and most of the impervious surfaces (in the form of high-intensity development) are located just upstream of the proposed action area (Kailua Bay Advisory Council 2007) (Figure 4-8). Discharge records from Heʻeia Stream at Haʻikū Valley, approximately 0.5 mile upstream of the proposed action area, indicate that high flows occur regularly in the watershed (U.S. Geological Survey [USGS] 2015) (Figure 4-9), and associated erosion and sedimentation are a concern for both the watershed and health of Kāneʻohe Bay. Coral health in the bay in particular has been negatively affected by nutrients and sediment-rich freshwater inputs (Guidry et al. 2013).

Actions that are part of the Māhuahua ʻAi o Hoi Project, independent of the proposed action, are likely to benefit the watershed and hydrology of the area. Invasive plants, such as California grass and other

nonnative plants that are constricting flows in the He‘eia Stream channel, are being removed, along with invasive mangrove trees in the upper intertidal area and fishpond, which are acting as a sediment trap, filling the fishpond and contributing to destabilization of the fishpond walls (Townscape 2011a). Also, detention ponds are being constructed in the southern portion of the proposed action area, to help detain sediments and debris during storm events and thus reduce impacts on wetlands and agricultural areas (Townscape 2011a).

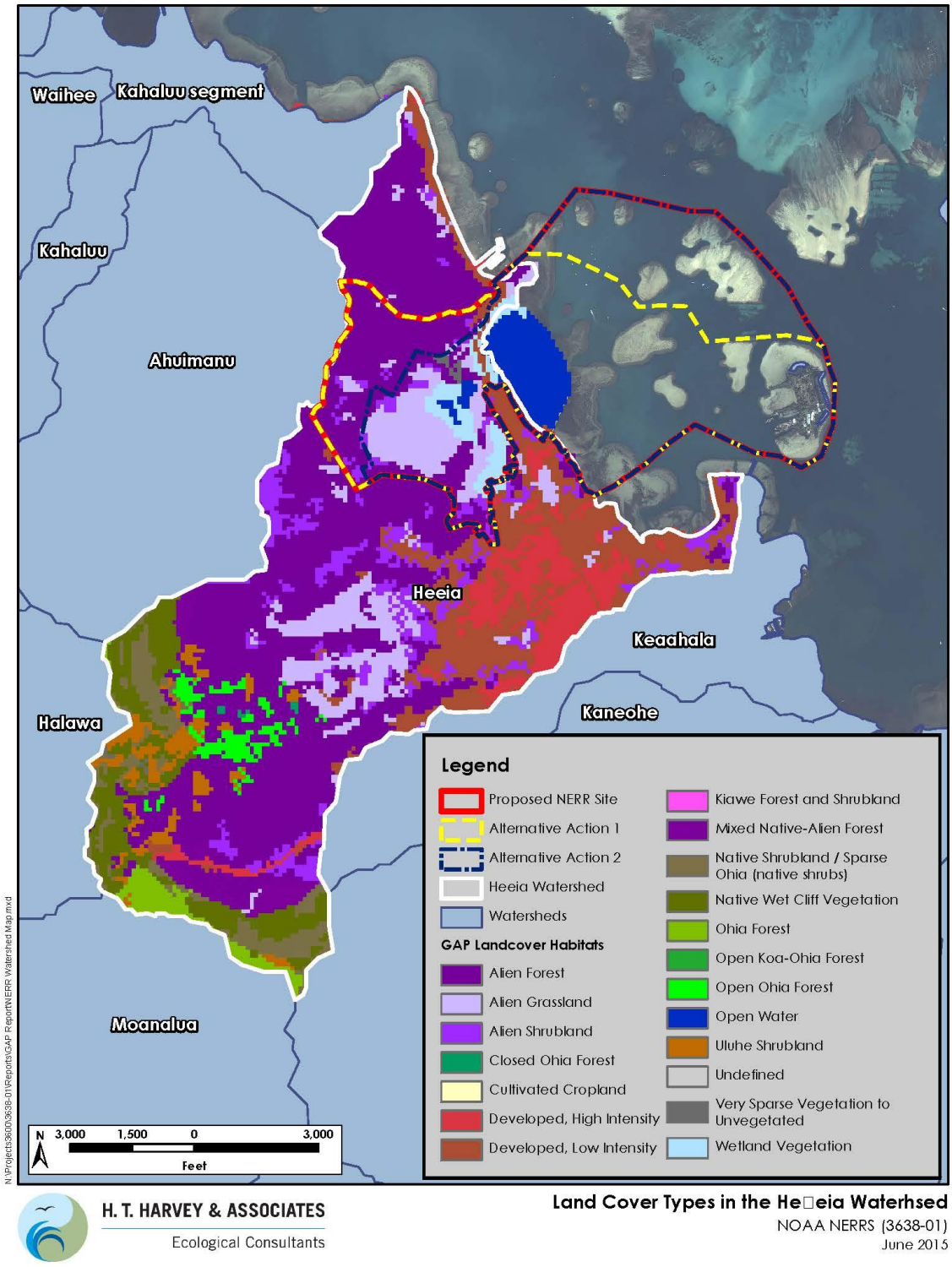


Figure 4-8. Land Cover Types in the He‘eia Watershed (Kailua Bay Advisory Council 2007)

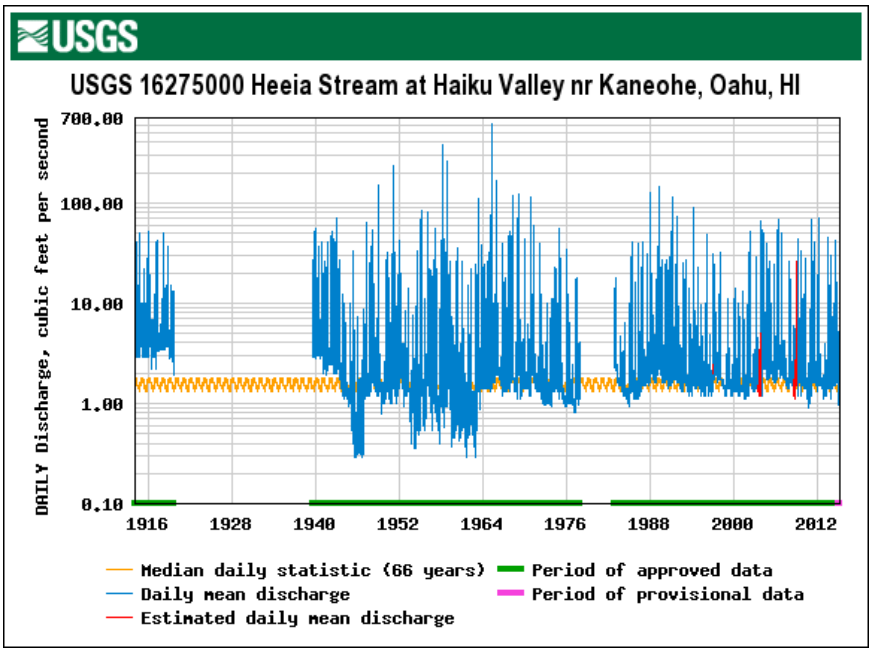


Figure 4-9. Daily Discharge of Fresh Water from He‘eia Stream (in Cubic Feet per Second) near Kāne‘ohe Valley, 1914–2014 (U.S. Geological Survey 2015)

Effect Types and Significance Criteria

Impervious-surface area is one of the most important indicators of watershed health, so additions of impervious surfaces would be considered to adversely affect the watershed (e.g., Arnold and Gibbons 1996; Booth et al. 2002, 2004). The proposed action is not likely to have any effect on impervious-surface area; however, high-density development just upstream of the proposed action area creates an already impacted condition that should be considered. Additionally, changes in the frequency or magnitude of peak flows could adversely affect the health of the watershed and water quality in Kāne‘ohe Bay.

Effects on hydrological and watershed characteristics would be considered significant if they involved substantial changes in the frequency and magnitude of peak flows in He‘eia Stream, or increases in the impervious-surface area in the He‘eia watershed.

Table 4-13. Information Available for Analysis of Watershed and Hydrological Effects

Potential Effect	Type and Scale of Information Needed to Support Significance Determination	Existing Sources	Is Sufficient Information Available?		
			Proposed Action	Alt. 1: Boundary Expansion (Uplands, Entire HCDA Parcel)	Alt. 2: Boundary Expansion (Outer Reefs)
Effects on watershed and hydrology	• Frequency and magnitude of peak flows • Impervious-surface area	• USGS 2015: Source provides current and historical discharge data. • Kailua Bay Advisory Council 2007: Source provides impervious-surface area.	Yes	Yes	Yes

Notes: Alt = Alternative; HCDA = Hawai‘i Community Development Authority; USGS = U.S. Geological Survey.
Yes = Existing sources are sufficient for analysis.

4.5 Water Quality

The water bodies in the proposed action and Alternative 2 areas consist of the perennial He‘eia Stream, the estuary, He‘eia Fishpond, and the semienclosed Kāne‘ohe Bay (Figure 2-1). Water quality in these water bodies is important, because it affects the health of fish and coral populations in the bay, the quality of drinking water, and the resilience of natural water systems in the face of climate change.

Observed water quality impairment in the area likely originates in the uplands. Runoff from uplands may contain sediments naturally eroding from forestlands; nitrates from fertilizer runoff, septic tanks, sewage, or erosion of natural deposits; and pollutants from urban development and road construction (Sumiye 2002). Nutrient and sediment-rich fresh water runs off into Kāne‘ohe Bay, especially during storm events, which induces phytoplankton blooms and threatens the health of the coral reefs in the bay (DeCarlo et al. 2007, Drupp et al. 2011, Guidry et al. 2013).

HIDOH is required by Clean Water Act Section 303(d) to report on the state’s water quality on a 2-year cycle, and to submit a list of waters that do not meet state water quality standards, plus a priority ranking of listed waters exceeding total maximum daily load (TMDL) standards, based on the severity of pollution and the uses of the waters (HIDOH 2014). Both He‘eia Stream and Kāne‘ohe Bay are on the list for nonattainment of one or more of the water quality standards, so their status is reported on a 2-year cycle (HIDOH 2014). As of 2014, He‘eia Stream had violated the standards for nitrate+nitrite-nitrogen (NO_3+NO_2) and total phosphorus (TP) during both the wet and dry seasons, but had attained the standard for turbidity, TSS, and total nitrogen (TN) (HIDOH 2014). Kāne‘ohe Bay (Central Region, in the proposed action area) had violated the standards for TN, NO_3+NO_2, ammonia-nitrogen (NH_3), and turbidity, but there was insufficient data to evaluate bacteria, TP, and chlorophyll-*a* (chl-*a*) (HIDOH 2014). Records of the water quality data used for this assessment were unavailable.

Effect Types and Significance Criteria

The Hawai‘i water quality standards are intended to establish the level of water quality necessary to protect existing uses (propagation of fish, shellfish, and wildlife, and recreation) (HIDOH 2014). These standards define the types of water quality effects that will be considered in the analysis of the proposed action and alternatives, because the standards identify water pollutants and characteristics that, if substantially altered, can cause adverse effects on humans and the environment. The standards set thresholds of acceptability for nutrients, turbidity, TSS, bacteria, heavy metals, pesticides, herbicides, and other potentially harmful substances. The thresholds will be used to determine the significance of any potential impacts.

Data on current water quality conditions are sufficient to establish baseline water quality levels and determine the significance of potential impacts. Although there is a lack of continuous-measurement data on water quality in Hawai‘i (DeCarlo et al. 2007), including in the proposed action area, the current status of water quality in He‘eia Stream and Kāne‘ohe Bay is known (HIDOH 2014), and several short-term water quality monitoring projects were identified for the He‘eia Stream, the He‘eia wetlands, He‘eia Fishpond, and Kāne‘ohe Bay that may be useful for evaluating the effects of the proposed action on water quality.

4.6 Geology

The proposed action and alternatives areas are located on the windward side of the Ko‘olau Mountains. The windward side of O‘ahu is characterized by steep cliffs and short ridges less than 4 miles long, topography that contributes to rapid runoff and low infiltration (Ko‘olau Mountains Watershed Partnership 2002). The soils in the proposed NERR, at the base of these mountains, are described below.

The soils in much of the He‘eia wetlands comprise mostly Hanalei silty clay (HnA) and Marsh soils (MZ) (Townscape 2011a) (Figure 4-10). In a typical profile, Hanalei silty clay is composed of poorly drained silty clay and silty clay loam from 0 to 36 inches in depth. This clay is frequently flooded and occasionally ponded, and has a moderate available water capacity. Marsh soil is composed of mucky peat from 0 to 60 inches in depth. It is very poorly drained, frequently flooded and ponded, and has a very high available water capacity.

The uplands to the north of the wetlands and in the Alternative 1 area are characterized as Waikane silty clay, with slopes of 25 to 40% (WpE) and Alaeloa silty clay, with 15 to 70% slopes (AeE and ALF). The hillside soils are silty and well drained, although they have less water capacity than the soils in the wetlands and are classified as highly erodible. Landslide areas are visible on the hillsides, and sheet/rill and road erosion are a concern (Townscape 2011a).

Table 4-14. Information Available for Analysis of Water Quality Effects

Potential Effect	Type and Scale of Information Needed to Support Significance Determination	Existing Sources	Is Sufficient Information Available?		
			Proposed Action	Alt. 1: Boundary Expansion (Uplands, Entire HCDA Parcel)	Alt. 2: Boundary Expansion (Outer Reefs)
Effects on water quality in He'eia Stream	Wet- and dry-season data for Sites 1 and 2[a] on N compounds (N, NO_3, NO_2, NH_3), TP, silica, DO, salinity, temperature, pH, and TSS, in support of State water quality standards and TMDLs	• HIDOH 2014: Source contains 2011–2013 data on N compounds, TP, and TSS. • Windward Community College 2005: Source contains 2002–2005 data on N compounds and TP. • EPA 2004: Source contains 2000–2004 data on N compounds, turbidity, DO, salinity, temperature, pH. • Hoover and Mackenzie 2009: Source contains 1999–2000 data on N compounds, TP, silica, and suspended particulate matter. • USGS 2015: Source contains 1983–1998 data on suspended sediment.	Yes	Yes	Yes
Effects on water quality in He'eia wetlands	Wet- and dry-season data for Site 3[a] on N compounds, TP, silica, DO, salinity, temperature, pH, and TSS, in support of State water quality standards and TMDLs	• Kobayashi 2001: Source contains 2000 data on N compounds, TP, and PCBs.	Yes	Yes	Yes
Effects on water quality in He'eia Fishpond	Wet- and dry-season data for Sites 4 and 5[a] on N compounds, TP, silica, DO, salinity, temperature, pH, TSS, and chl-*a*, in support of State water quality standards and TMDLs	• Young 2011: Source contains 2007 data on N compounds, TP, phosphate, DOC, TSS, alkalinity, and chl-*a*.	Yes	Yes	Yes
Effects on water quality in Kāne'ohe Bay	Wet- and dry-season data for Sites 6–8[a] on N compounds, TP, silica, DO, salinity, temperature, pH, TSS, and chl-*a*, in support of State water quality standards and TMDLs	• HIDOH 2014: Source contains 2011–2013 data on N compounds and turbidity. • Drupp et al. 2011, Solomon 2008: Sources contain 2005–2008 data on N compounds, phosphate, silica, chl-*a*, and CO_2 at CRIMP CO_2 buoy in Kāne'ohe Bay. • DeCarlo et al. 2007: Source contains 2003–2004 data on N compounds, TP, phosphate,	Yes	Yes	Yes

	chl-*a*, TSS, DO, salinity, and temperature at CRIMP CO_2 buoy in Kāneʻohe Bay. • Fagan and Mackenzie 2007: Source contains 2003–2004 data on DOC and alkalinity at several sites in bay. • Windward Community College 2005: Source contains 2002–2005 data on N compounds and TP. • Ringuet and Mackenzie 2005: Source contains 2001–2003 data on N compounds, TP, phosphate, silica, chl-*a*, and TSS near Moku o Loʻe. • Cox and University of Hawaiʻi at Mānoa 2010: Source contains 1998–2001 data on N compounds, phosphate, silica, TSS, temperature, salinity, and chl-*a*.	

Notes: Alt = Alternative; chl-a = chlorophyll-*a*; CO_2 = carbon dioxide; DO = dissolved oxygen; DOC = dissolved organic carbon; EPA = Environmental Protection Agency; HCDA = Hawaiʻi Community Development Authority; HIDOH = Hawaiʻi Department of Health; N = nitrogen; PCBs = polychlorinated biphenols; TMDLs = total maximum daily loads; TP = total phosphorus; TSS = total suspended solids; USGS = U.S. Geological Survey, CRIMP CO_2 buoy = Coral Reef Instrumented Measurement and CO_2 Monitoring Platform buoy

Yes = Existing sources are sufficient for analysis.

[a] = Monitoring sites shown in Windward Community College 2005.

The shoreline of Kāneʻohe Bay is ringed by shallow fringing reefs, and the bay has numerous patch reefs that occur less than 3.3 feet from the surface and are partially exposed during extreme spring tides (Jokiel 1991). Several of these patch reefs are found in the proposed action and Alternative 2 areas. The bottom of Kāneʻohe Bay consists of coral rubble, gray coral muds, and fine coral sands, with fine brown silts and clays nearshore, especially near stream mouths (Jokiel 1991). Four major islands and islets are located in Kāneʻohe Bay: Kapapa, Mokoliʻi (Chinaman's Hat), Kekepa (Turtleback Rock), and Moku o Loʻe. The 28-acre Moku o Loʻe is the only one of the four that is situated in the proposed action area; this island is a basaltic outcrop formed by the old Koʻolau volcano and is surrounded by fringing reefs (Jokiel 1991).

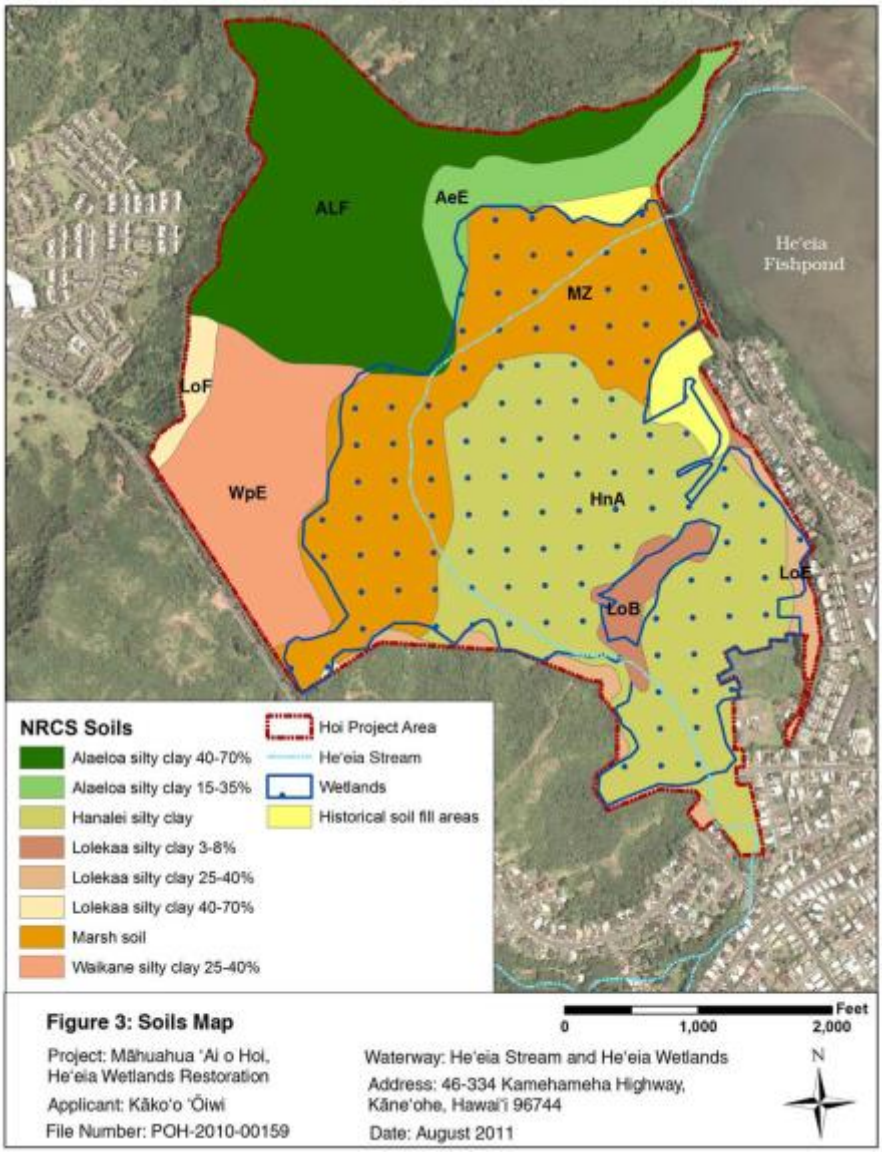


Figure 4-10. Soil Map for the Proposed Action and Alternative 1 Areas (Townscape 2011a)

Effect Types and Significance Criteria

The proposed action or alternatives could result in increased erosion, subsidence, or landslides. The removal of mangroves or other invasive vegetation in the proposed action area could cause increased sedimentation downstream. Because the terrestrial uplands in the Alternative 1 area have highly erodible soils, Kakoʻo ʻŌiwi's planned activities, which involve removal of invasive plant cover to cultivate dryland crops and orchards, could increase erosion and thereby affect downstream areas. Erosional effects would be considered significant if they resulted in a violation of the State standards for TSS in receiving water

bodies—He‘eia Stream TSS levels would be most indicative of adverse effects. Current data on He‘eia Stream TSS levels are sufficient to determine the significance of any potential impacts.

Table 4-15. Information Available for Analysis of Geological Effects

Potential Effect	Type and Scale of Information Needed to Support Significance Determination	Existing Sources	Is Sufficient Information Available?		
			Proposed Action	Alt. 1: Boundary Expansion (Uplands, Entire HCDA Parcel)	Alt. 2: Boundary Expansion (Outer Reefs)
Effects of erosion on He‘eia Stream	Wet- and dry-season data for Sites 1 and 2[a] on TSS in support of State water quality standards and TMDLs.	• HIDOH 2014: Source provides 2011–2013 data on TSS. • Hoover and Mackenzie 2009: Source provides 1999–2000 data on suspended particulate matter. • USGS 2015: Source provides 1983–1998 data on suspended sediment.	Yes	Yes	Yes

Notes: Alt = Alternative; HCDA = Hawai‘i Community Development Authority; HIDOH = Hawai‘i Department of Health; TMDLs = total maximum daily loads; TSS = total suspended solids; USGS = U.S. Geological Survey.

Yes= Existing sources are sufficient for analysis.

[a] = Monitoring sites shown in Windward Community College 2005.

4.7 Climate

The windward side of O‘ahu, where the action area is located, experiences cooler temperatures and higher rainfall than the leeward side of the island. Trade winds from the northeast bring warm moist air to land. The moisture is deflected up along the Ko‘olau Mountains where the warm air cools, forms clouds, and releases rain. The mountains above the action area receive frequent rainfall, whereas the coastal areas receive moderate to frequent rainfall (Giambelluca et al. 2013) (Figure 4-11), most of which occurs from October through May, with occasional heavy storms. The average annual air temperature ranges from 71 to 85°F, averaging 78°F (U.S. Climate Data 2015).

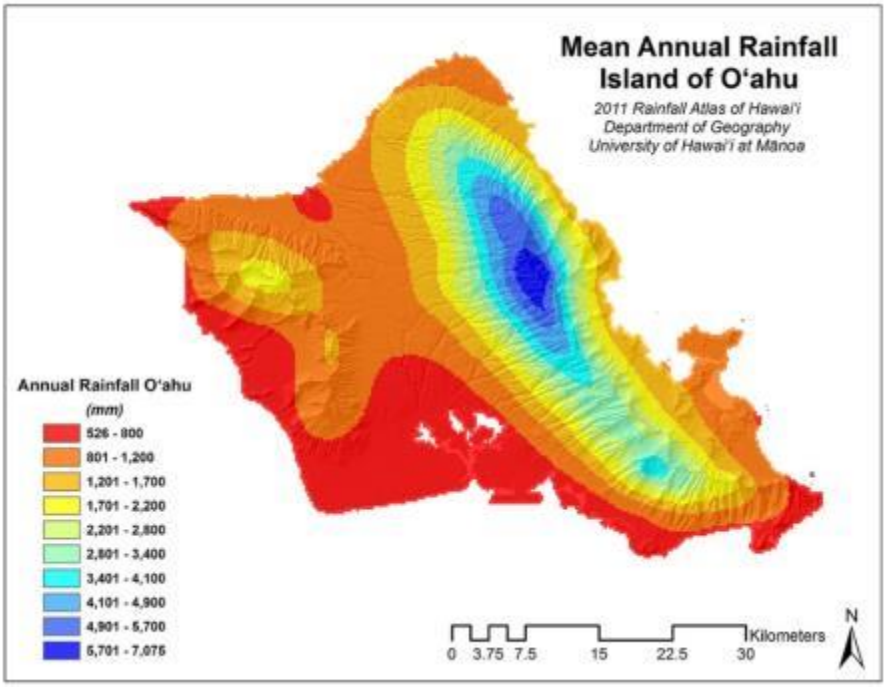


Figure 4-11. Mean Annual Rainfall on the Island of Oʻahu, 1978–2007 (Giambelluca et al. 2013)

Climate change in the Hawaiian Islands has been observed and is predicted to continue in the form of rising sea surface and air temperatures, sea level rise, ocean acidification, and declining rainfall and streamflows, with more of the rainfall occurring in intense downpours (Codiga and Wager 2011, Nurse et al. 2014). Ocean acidification, caused by rising atmospheric carbon dioxide concentrations and subsequent increases in dissolved inorganic carbon and carbon dioxide in ocean waters, may reduce the recruitment rate and growth of corals in Kāneʻohe Bay (Jokiel et al. 2008, Kuffner et al. 2008). Sea level rise, which is predicted to be approximately 1 foot by 2050 and 3 feet by 2100 (Codiga and Wager 2011), could result in saltwater intrusion into the Heʻeia wetlands and taro ponds, and may overtop the fishpond walls. Changes in rainfall patterns to more intense downpours could affect hydrology and decrease water quality in Heʻeia Stream and Kāneʻohe Bay.

Methane emissions from the Heʻeia wetlands could exacerbate climate change impacts—wetlands are a natural source of methane, which is a greenhouse gas (Mitsch et al. 2013). However, tropical wetlands are predicted to function as a net carbon and radiative sink within the next 300 years and balance out the methane emissions (Mitsch et al. 2013). The Heʻeia wetlands may also provide a natural flood buffer that accommodates sea-level rise without the need for additional hard armoring or other measures to protect upstream urban development (Codiga and Wager 2011). Therefore, the Heʻeia wetlands may increase the overall resilience of the ecosystem to climate change.

Effect Types and Significance Criteria

Potential climate-related effects include both the effects of the proposed action on climate change and the effects of climate change on the proposed action. The former could occur through exacerbation of existing climate change impacts, or via a change (increase or decrease) in the resilience of the ecosystem to climate change. However, the proposed action and alternatives are not anticipated to have negative effects on climate change. Any such effects would be considered significant if the potential for He‘eia wetlands to sequester carbon were not expected to balance out methane emissions, but this is not predicted to occur for tropical wetlands in general. Other types of potentially significant negative effects on climate change, such as an increase in greenhouse gas emissions (e.g., due to an increase in vehicular traffic), are not expected to occur as a result of the proposed action.

There are several ways in which climate change could negatively affect the proposed action: changes in rainfall patterns could affect water quality and hydrology, sea-level rise could overtop or affect the stability of the fishpond walls, and ocean acidification could affect coral recruitment and survival in Kāne‘ohe Bay. These potential negative effects could occur, and should be considered during the planning and implementation of all project activities.

4.8 Cultural Resources

The proposed action and alternatives areas have been subject to numerous archaeological and cultural resource studies (McAllister 1933, Yent and Griffin 1977, Kawachi 1990, Nagata 1992, Henry 1993, Freeman and Hammatt 2004, Carson 2006, Altizer 2011, Groza and Monahan 2012, Cruz and Hammatt 2012, Soltz et al. 2014). McAllister (1933) was the first to document the major sites around O‘ahu; with regard to the action area, he documented three cultural sites: He‘eia Fishpond, Kaualauki Heiau, and the dwelling place of Meheanu at Luamo‘o. Surface and subsurface archaeological surveys of He‘eia-Matson Point State Park in 1977 (Yent and Griffin 1977) did not report any significant findings. However, relevant to the area, a 1982 report documented iwi (ancestral remains) at He’eia State Park, a discovery that was confirmed by a 1992 (Nagata 1992) archaeological survey of the same parcel. An archaeological and cultural impact study conducted for the Kamehameha waterline project did not identify any historic properties or traditional cultural practices, but, Ke‘alohi Point was noted as leina ‘uhane (a place where the souls of the dead leaped into the nether world) (Freeman and Hammatt 2004).

Table 4-16. Information Available for Analysis of Climate-related Effects

Potential Effect	Type and Scale of Information Needed to Support Significance Determination	Existing Sources	Is Sufficient Information Available?		
			Proposed Action	Alt. 1: Boundary Expansion (Uplands, Entire HCDA Parcel)	Alt. 2: Boundary Expansion (Outer Reefs)
Exacerbation of existing climate-related effects	• Methane emissions from He‘eia wetlands	Mitsch et al. 2013: Source describes potential climate change impacts of methane emissions in tropical wetlands.	Yes	Yes	Yes
Change in ecosystem resilience to climate effects	• Carbon sequestration provided by He‘eia wetlands • Natural flood buffer provided by He‘eia wetlands	Codiga and Wager 2011, Mitsch et al. 2013: Sources describe potential for tropical wetlands to sequester carbon and act as flood buffers.	Yes	Yes	Yes
Potential effects of climate change on project activities	• Predicted climate effects on water quality and hydrology of He‘eia Stream and Kāne‘ohe Bay • Predicted sea level rise and resultant effects on fishpond and He‘eia wetlands • Predicted ocean acidification and resultant effects on corals in Kāne‘ohe Bay	Jokiel et al. 2008, Kuffner et al. 2008, Codiga and Wager 2011: Sources provide predictions as noted.	Yes	Yes	Yes

Notes: Alt = Alternative; HCDA = Hawai‘i Community Development Authority.
Yes = Existing sources are sufficient for analysis.

An archaeological assessment of the replacement of the caretaker’s house at He‘eia Fishpond also did not identify any surface or subsurface cultural resources (Carson 2006). Work conducted within the boundaries of the He‘eia Fishpond identified no specific cultural resources other than the fishpond itself (Cruz and Hammatt 2012). A literature review and field inspection for the He‘eia Fishpond wall repair project determined that no adverse effects on cultural resources would result, and recommended no further archaeological work (Grozo and Monahan 2012). A separate cultural impact assessment (CIA) done for the He‘eia Fishpond involved community consultation and formal interviews (Cruz and Hammatt 2012). This CIA discussed the important relationship between the He‘eia Fishpond and inland lo‘i kalo, which mitigated the effects of flooding on the fishpond. The CIA also discussed that the fishpond may include Traditional Cultural Properties [TCPs] of ongoing cultural significance that may be included in the Hawai‘i Register of Historic Places. However, the CIA concluded that the fishpond wall repairs would not adversely affect cultural practices or resources.

Literature and field review for portions of the Māhuahua ʻAi o Hoi project site documented a precontact basalt quarry, the foundation of an ʻokole hao distillery, two ranching enclosures, fences and roads (possibly related to agriculture), and possible subsurface loʻi berms (Altizer 2011). Additional work conducted at the Kakoʻo ʻŌiwi property identified the following 17 sites (Soltz et al. 2014):

- Site 7521, plantation-era road
- Site 7522, basalt quarry with traditional debitage
- Site 7523, concrete foundation, possibly for ʻokole hao distillery
- Site 7524, ranching-era enclosure
- Site 7525, ranching-era enclosure
- Site 7526, glass and ceramic fragment scatter
- Site 7527, glass and ceramic fragment scatter and three depression features
- Site 7528, four plantation-era depressions with glass and ceramic fragments
- Site 7529, stone and mortar L-alignment
- Site 7530, complex of five terraces and two mounds
- Site 7531, World War II–era earthen terrace and foxhole depressions
- Site 7532, plantation-era road, possibly to/from rice mill
- Site 7533, plantation-era bridge
- Site 7534, plantation-era ʻauwai (ditch, canal)
- Site 7535, two concrete platforms/foundations, possibly for rice mill
- Site 7536, ranching-era wooden and metal cattle run
- Site 7537, subsurface loʻi and rice berms

Four of these sites could be affected by the proposed action or alternatives: the basalt quarry (Site 7522) and an agricultural complex (Site 7530), both of which predate the first arrival of Europeans sailors in 1778, and the postcontact (i.e., postdating 1778) remains of a rice mill (Site 7535) and of an ʻokole hao distillery (Site 7523) (Figure 4-12).

Effect Types and Significance Criteria

Few adverse effects on cultural resources are expected to result from the proposed action or alternatives. The He'eia Fishpond is not expected to be affected. Likewise, the proposed action would not affect subsurface cultural resources inland. No archaeological resources have been identified in the Alternative 2 outer reefs, and any as-yet undiscovered resources that are encountered during implementation of the proposed action (for example, resources discovered in the bay) would be addressed appropriately through standard protocols.

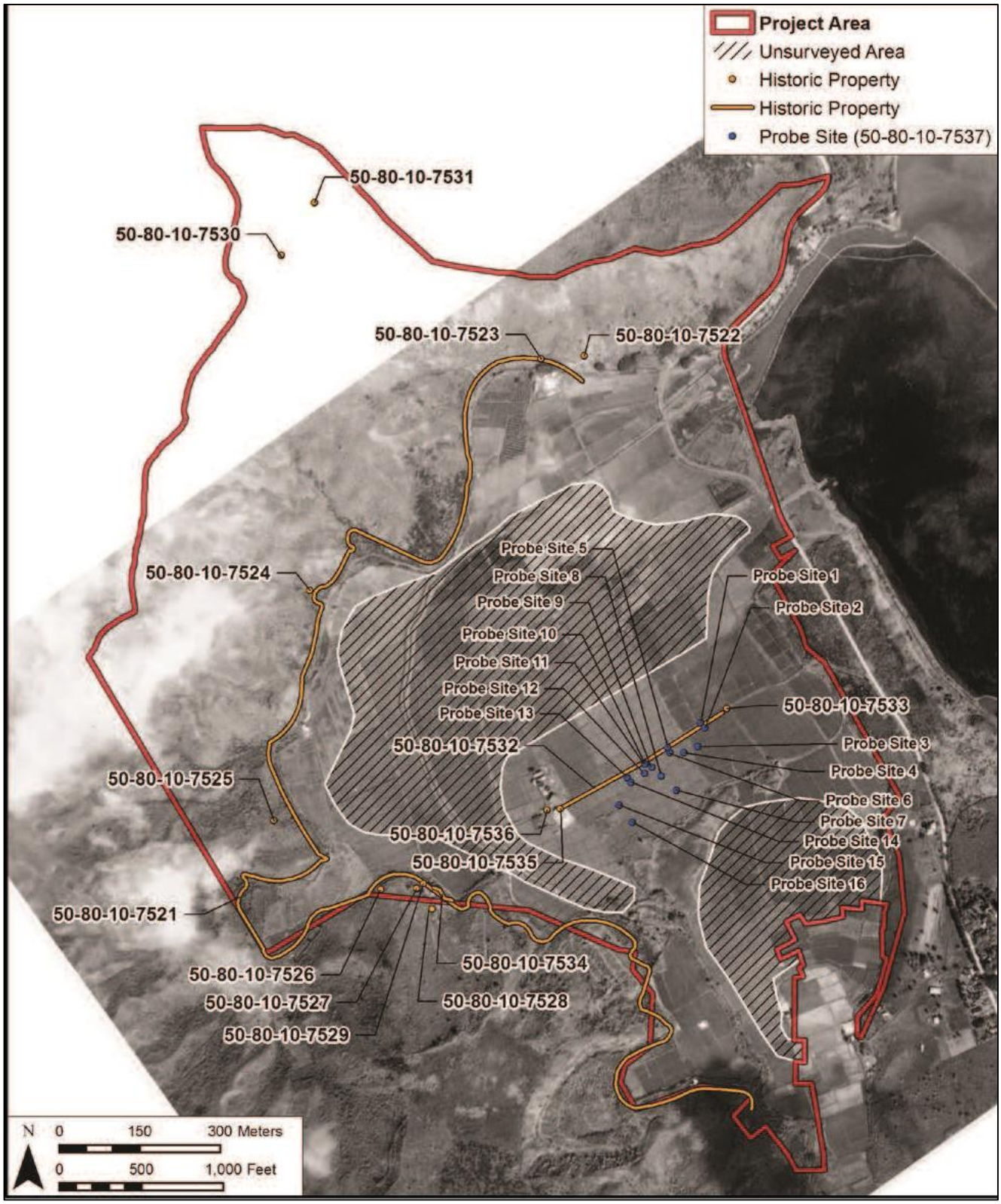


Figure 4-12. Location of Archaeological Features Found in Kakoʻo ʻŌiwi–Managed Lands at the Heʻeia NERR Site (Reproduced from: Soltz et al. 2014)

The only cultural resources that may be affected by the proposed action or alternatives would be the basalt quarry, an agricultural complex, and postcontact ʻokolehao distillery and rice mill remains. Effects on these sites would be considered significant if their removal or modification were required.

Table 4-17. Information Available for Analysis of Cultural Resources Effects

			Is Sufficient Information Available?		
Potential Effect	**Type and Scale of Information Needed to Support Significance Determination**	**Existing Sources**	**Proposed Action**	**Alt. 1: Boundary Expansion (Uplands, Entire HCDA Parcel)**	**Alt. 2: Boundary Expansion (Outer Reefs)**
Potential effect on the remains of documented archaeological sites such as the postcontact ʻokolehao distillery and rice mill	Inventory of surface cultural resource sites	McAllister 1933, Yent and Griffin 1977, Kawachi 1990, Nagata 1992, Henry 1993, Freeman and Hammatt 2004, Carson 2006, Altizer 2011, Groza and Monahan 2012, Cruz and Hammatt 2012, Soltz et al. 2014: Sources consist of cultural resource inventories and studies in the action area. Also, community consultation has been conducted for properties in the proposed action area. These oral histories provide valuable traditional knowledge and history of the area.	Yes	Yes	Yes
Effects on as-yet undiscovered cultural resources	None	None; e.g., no marine archaeological surveys have been completed in the action area.	Yes	Yes	Yes

Notes: Alt = Alternative; HCDA = Hawaiʻi Community Development Authority.
Yes = Existing sources are sufficient for analysis.

4.9 Socioeconomic Characteristics

The immediate area of potential socioeconomic effect for the proposed action is the Heʻeia NERR site itself; changes within the NERR could affect residents and organizations in the surrounding area. That surrounding area is defined as the 96744 Zip Code Tabulation Area (ZCTA), covering the various civilian communities located on and around Kāneʻohe Bay. Also, economic impacts of the designation could have indirect and induced impacts on a wider scale, for which the State of Hawaiʻi is the potentially affected area.

Kāneʻohe Bay is a recreation resource used by residents of nearby communities and appreciated by both residents and visitors to Oʻahu. The bay is a major resource for research on tropical marine environments, thanks to continuing research programs based at HIMB (HIMB 2010). As described earlier, the bay and the Heʻeia estuary have been affected by urbanization of the surrounding area and lack of long-term coordinated stewardship of resources (OP 1992); in response, the parties collaborating in the NERR planning effort have been working to restore the bay, estuary, and the Heʻeia ahupuaʻa (i.e., the cultural division of land) (PBR Hawaiʻi 2014).

The Kāneʻohe Bay region combines suburban and rural areas. The population is nearly 54,000.[2] The median age is 41.5 years old. The median household income ($85,608) is 127% of the state median. Major highways run through the Koʻolau Mountains to the leeward side of the island and parallel to the coast. The stretch of Kamehameha Highway in the action area is a two-lane roadway; farther inland, Kahekili Highway is the major route for travel to the North Shore.

Effect Types and Significance Criteria

Executive Orders (EOs) 12898 and 13045 address the potential socioeconomic impacts of federal actions. These EOs are concerned with disproportionately adverse human health or environmental effects on minority or low-income populations, and with impacts on the health of children. Associated significance criteria have been set out by federal agencies and clarified in the course of reviews of EISs by agencies (such as the U.S. Environmental Protection Agency) and through judicial reviews.

Additional types of socioeconomic impacts can be identified by the level of contention that occurs over an issue, or by predicting that an action will result in changes in human use of resources. Below are three broad categories of socioeconomic effects that could result from the proposed action or alternatives, and their associated significance criteria:

- **Reduced Access to Fishing Resources.** In Hawaiʻi, the distinctions between recreational, subsistence, and commercial fishing can be blurred. It is generally agreed that fish stocks throughout the islands have declined. Kāneʻohe Bay fishers report a decline in stocks throughout the twentieth century. NERR activities could increase community support and interest in reef and fisheries conservation, and thus could change public sentiment to seek greater fishing restrictions in the NERR. Likewise, an increase in publicity about NERR resources could attract more fishers to the area and thereby affect both the availability of fish and current local fishers' access to the fisheries. However, NERR conservation and restoration activities could improve habitat and increase fish stocks, making more fish available to local fishers. In general, the potential negative effects on fisheries are clearly contentious, and the available resource is limited, so any further decline or restriction of access would be considered significant. The Division of Aquatic Resources

[2] U.S. Bureau of the Census, American Community Survey, 5-year data for 2009–2013 for the Kāneʻohe ZCTA (96744), which includes lands fronting the bay from Kāneʻohe to Kualoa.

(DAR) currently collects recreational fishing data statewide under the Hawai‘i Marine Recreational Fishing Survey project, and Kāne‘ohe Bay is included as a data collection site (DAR unpublished data). Although they are not routinely published in a form summarized by site, the existing data are available to track changes in future fishing participation and success.

- **Changes in Population, Jobs, Public Facilities, or Infrastructure.** The proposed action area is small and lightly populated, relative to both the Kāne‘ohe Bay region and the state as a whole. The NERR’s effects on local jobs might be large in comparison to the current modest employment opportunities provided by preservation and research efforts in the action area, but modest relative to employment in the surrounding community and state. Increased activity associated with the NERR is expected to bring a few more people to the region, and hence increase traffic on Kamehameha Highway, but otherwise will have minimal impacts on public facilities and infrastructure. As a rule of thumb, estimated changes that represent less than 5% of current or estimated levels of usage are considered unlikely to be significant.
- **Increased Costs for Local Operations Owing to Regulation and Oversight**. Implementation of the NERR management plan will support restoration and research efforts at the site. The increased attention of local, State, and federal agencies and the community to improving the area could result in increased public and agency support and advocacy for protection and preservation of resources. In fact, questions voiced by members of the He‘eia community reflect considerable concern that the NERR designation will result in higher levels of environmental review or restrictions on community activities, such as the cultural, recreational, or commercial activities now occurring, including beneficial restoration activities. NOAA and OP have informed the public that a NERR designation does not add new regulations on uses or activities within the NERR boundaries, but many community members have asked for some form of assurance. NOAA cites its authorizing regulations to underscore its intent (NOAA 2003), but because this is a new NERR site, and no local data are available on how other agencies and community members will react to the development of the NERR, concerns have persisted. Designation and management of the NERR could result in general positive community involvement and processes for resolution of user conflicts. However, a designation also could result in new environmental oversight of the site partners’ operations and restoration activities, increasing the time and costs involved in implementing beneficial projects, or creating restrictions on commercial and recreational activities in the NERR.

Table 4-18. Information Available for Analysis of Socioeconomic Effects

Potential Effect	Type and Scale of Information Needed to Support Significance Determination	Existing Sources	Is Sufficient Information Available?		
			Proposed Action	Alt. 1: Boundary Expansion (Uplands, Entire HCDA Parcel)	Alt. 2: Boundary Expansion (Outer Reefs)
Disproportionately adverse effects on minority or low-income populations; effects on children's health	Demographic and socioeconomic data	• U.S. Bureau of the Census, 2010 Census and 2009–2013 American Community Survey • U.S. Census, Zip Code Business Patterns (annual, 1998–2012)	Yes	Yes	Yes
Change in access to and availability of fish for local fishers	Catch data for fishing in Kāneʻohe Bay	• Interviews with local fishers (anecdotal) • Recreational fishing surveys (DAR unpublished data)	Yes	Yes	Yes
Change in marine recreational activity	Estimated intensity of current usage	• Interviews with local experts • Clark 2005: Beach inventory	Yes	Yes	Yes
Changes in traffic on nearby roadways	Recent traffic counts	• Department of Transportation–Highways and County Department of Transportation Services traffic count data	Yes	Yes	Yes
Change in research funding or oversight for HIMB	• Trend data from HIMB • Comparative data for other NERR sites	• HIMB records, interviews	Yes	Yes	Yes
Increased yield from wetland and fishpond	Current yields	• Interviews with operators	Yes	Yes	Yes
Impact on property development or values, nearby residential areas	• Inventory of nearby residential parcels • Local historical data on resale trends	• Honolulu Real Property TMK database • Resale trend data compiled by realtors	Yes	Yes	Yes
Effects related to job creation	Input-output model of the regional economy	• 2007 Inter-County input output model	Yes	Yes	Yes
Increased costs for local operations owing to regulation and oversight	Comparative data for other NERR sites	None	No	No	No

Notes: Alt = Alternative; DAR = Division of Aquatic Resources; HCDA = Hawaiʻi Community Development Authority; HIMB = Hawaiʻi Institute of Marine Biology; NERR = National Estuarine Research Reserve; TMK = Tax Map Key.

No = Further information needed.

Yes = Existing sources are sufficient for analysis.

Section 5. Findings and Recommendations

5.1 Findings

This gap analysis finds that sufficient information is available regarding natural, cultural, and socioeconomic resources to support programmatic analysis of project effects under NEPA, with one exception, relating to socioeconomic effects.

Questions voiced by members of the He‘eia community reflect considerable concern that the NERR designation will result in higher levels of environmental review or restrictions on community activities, including new environmental oversight of the site partners’ operations and restoration activities, increasing the time and costs involved in implementing beneficial projects. Therefore, the programmatic NEPA analysis of socioeconomic effects would benefit greatly from any available data or research from other NERR sites that demonstrate that the NERR designation will not result in regulatory restrictions or increased reviews, consistent with NOAA’s stated intent for the He‘eia site. Resolving this question is a high priority.

5.2 Recommendations for Research or Studies

The research described in Section 5.2.1 is recommended to address the identified socioeconomic information gap for the current NEPA analysis. Section 5.2.2 lists studies recommended to support future environmental analysis of site-specific projects that may occur under the framework of the NERR.

5.2.1 Conduct a Survey of NERR Reserve Managers

Implementation of the NERR management plan will support restoration and research efforts at the site. Local, State, and federal agency and community attention to improving the area is likely to follow. The best sources for assessing the extent and impact of new agency and community involvement are the reserve managers of existing NERRs in other states and their local community stakeholders, such as a reserve’s “Friends Group” or local fishing clubs. A two-phase electronic survey of reserve managers and stakeholders is recommended. The first phase would involve sending a survey to the managers, and the second phase would reach out to local stakeholders identified by the managers. The surveys could address short-term and midterm impacts related to the following topics:

- The extent of community involvement in the NERR
- Whether the NERR’s programs and organization work to resolve community differences regarding natural resource management in the NERR.

- Whether the NERR's community outreach committees and advisory bodies work to mitigate or limit user conflicts
- The type and extent of economic impacts on the immediately surrounding community
- The extent of impacts on local roadways and traffic volumes
- Changes in recreational activities enjoyed by NERR neighbors and by people coming from outside the immediate area
- Changes in fishing regulations in the NERR
- Whether the community is satisfied with the NERR designation
- Whether the NERR designation limits or changes environmental oversight of activities in the NERR, and whether that impact is burdensome

5.2.2 Conduct Recommended Studies for Future Site-specific Projects

(1) **Establish Baseline Data on Water Quality.** There is a lack of consistent long-term monitoring data to document whether project sites meet State water quality standards and TMDLs. As of 2014, He'eia Stream and Kāne'ohe Bay were on the HIDOH list for nonattainment of one or more water quality standards. Information on water quality baselines and potential effects of NERR project activities will be needed to conduct NEPA and HEPA analyses for future NERR projects. Water quality monitoring should be conducted for He'eia Stream (upstream of and within the proposed NERR site), the He'eia wetlands, He'eia Fishpond, and Kāne'ohe Bay to establish baseline conditions for any site-specific projects that will require NEPA or HEPA review. In addition, stream quality could be measured for He'eia Stream using the invertebrate community index developed for O'ahu (Wolff 2012). Lastly, the He'eia NERR management plan should include long-term water quality monitoring as a core program function and as part of the NERRS nationwide water quality monitoring program.

(2) **Conduct Baseline Surveys for Threatened and Endangered Species.** Listed waterbirds occasionally occur in the Kāko'o 'Ōiwi wetland areas, and there is potential for populations to increase. Existing studies are adequate to identify the current sporadic presence of waterbirds in wetland areas. However, baseline information on endangered waterbird presence and status, habitat use, and causes of mortality will be needed to conduct NEPA and HEPA analyses for future NERR site-specific projects. It is recommended that a baseline survey for endangered waterbirds and other listed threatened or endangered species be conducted for any future project that will require NEPA or HEPA analysis, as part of that project's planning process. It is also recommended that an endangered waterbird monitoring program be developed and implemented as part of the resource protection activities prescribed by the NERR management plan. The NERR research coordinator or reserve manager should ensure that the He'eia wetland complex continues to be included in future biannual statewide waterbird surveys conducted by DOFAW, and that those survey results are included in the NERR research database.

(3) **Conduct Quantitative Surveys for Native Flora and Fauna.** Although several floristics inventories have been conducted in the action area, none of these surveys has provided quantitative measures of the abundance of native plants or invasive plant species. Likewise, brief surveys of terrestrial fauna have been done, but these are not current or site specific. Existing studies are adequate to identify the rare occurrence and limited range of native plants and the occurrence of nonnative plants and common terrestrial fauna in the action area. However, quantitative baseline data on the distribution and status of native and nonnative flora and fauna will be useful in NEPA and HEPA analyses for future NERR site-specific projects. It is recommended that a quantitative baseline survey for native plants, invasive species, and common terrestrial fauna be conducted for any future project that will require NEPA or HEPA analysis, as part of that project's planning process.

(4) **Conduct Baseline Archaeological Surveys.** Few adverse effects on cultural resources are expected to result from the proposed designation of He'eia as a NERR. The He'eia Fishpond and subsurface cultural resources inland are not expected to be affected. The cultural resources that may be affected by the proposed action or alternatives would be the postcontact would be the basalt quarry, an agricultural complex, and postcontact 'okolehao distillery and rice mill remains. For any future NERR project that will require NEPA or HEPA review and that occurs in the vicinity of the 'okolehao distillery or rice mill sites, baseline information on the location and status of aboveground and subsurface cultural resources will be needed.

Section 6. Acknowledgements

The authors of this report and the State Office of Planning would like to thank the staff of Hawai‘i Institute of Marine Biology, He‘eia State Park, Paepae o He‘eia, Kāko‘o ‘Ōiwi, Ko‘olaupoko Civic Club, Ko‘olau Foundation, and Townscape, Inc., for helping gather the literature resources necessary to conduct this gap analysis. Also, we thank the local fishermen and boat operators from the community who graciously offered their time for interviews necessary for conducting this gap analysis for the programmatic EIS for the He‘eia NERR.

Section 7. References

Aeby, G. S., J. C. Kenyon, J. E. Maragos, and D. C. Potts. 2003. First record of mass coral bleaching in the Northwestern Hawaiian Islands. Coral Reefs 22:256.

Aguirre, A. A., T. J. Keefe, J. S. Reif, L. Kashinsky, P. K. Yochem, J. T. Saliki, J. L. Stott, T. Goldstein, J. P. Dubey, R. Braun, and G. Antonelis. 2007. Infectious disease monitoring of the endangered Hawaiian monk seal. Journal of Wildlife Diseases 43(2):229–241.

Altzier, K., J. Lance, and H. H. Hammatt. 2011. Draft Archaeological Literature Review and Field Inspection for the Māhuahua ʻAi o Hoi: Heʻeia Wetland Restoration Project, Heʻeia Ahupuaʻa, Koʻolaupoko District, Oʻahu Island. TMK: (1) 4-6-016:001 and 002. Cultural Surveys Hawaiʻi, Kailua.

Arnold, C. A., Jr., and C. J. Gibbons. 1996. Impervious surface coverage: the emergence of a key urban environmental indicator. Journal of the American Planning Association 62(2):243–258.

Asner, G. P., and S. W. Beatty. 1996. Effects of an African grass invasion on Hawaiian shrubland nitrogen biogeochemistry. Plant and Soil 186(2):205–211.

Bahr, K. D., P. L. Jokiel, R. J. Toonen. In preparation. The Unnatural History of Kāneohe Bay: Coral Reef Resilience in the Face of Centuries of Anthropogenic Impacts. Hawaiʻi Institute of Marine Biology, University of Hawaiʻi, Honolulu.

Baker, J. D., A. L. Harding, T. A. Wurth, and T. C. Johanos. 2011. Dramatic shifts in Hawaiian monk seal distribution predicted from divergent regional trends. Marine Mammal Science 27:78–93.

Balazs, G. H., S. K. K. Murakawa, D. M. Ellis, and A. A. Aguirre. 1998. Manifestation of Fibropapillomatosis and Rates of Growth of Green Turtles at Kāneʻohe Bay in the Hawaiian Islands. Proceedings of the 18th International Symposium on Sea Turtle Biology and Conservation.

Bishop Museum. 2010. Waipio Valley Stream Restoration Study. Hawaiʻi Biological Survey, Honolulu.

Booth, D. B., D. Hartley, and R. Jackson. 2002. Forest cover, impervious-surface area, and the mitigation of stormwater impacts. Journal of the American Water Resources Association 38(3):835–947.

Booth, D. B., J. R. Karr, S. Schauman, C. P. Konrad, S. A. Morley, M. G. Larson, and S. J. Burges. 2004. Reviving urban streams: land use, hydrology, biology, and human behavior. Journal of the American Water Resources Association 40(5):1354–1361.

Brainard, R. 2002. Bleaching in NW Hawaiian Islands. Bleaching Report, National Environmental Satellite, Data, and Information Service. ORA/ORSPD Coral Reef Team, Coral Reef Bleaching Hotspots. <http://www.osdpd.noaa.gov/PSB/EPS/SST/data/als_bleaching.10.16.2002>

Brooks, M. 1991. Final Environmental Assessment for Conservation District Use Application OA-10/28/91-2530 for Commercial Aquaculture at Heʻeia Fish Pond, Koʻolaupoko, Oʻahu, HI.

Buddemeier, R.W., P. L. Jokiel, K. M. Zimmerman, D. R. Lane, J. M. Carey, G. C. Bohling, and J. A. Martinich. 2008. A modeling tool to evaluate regional coral reef responses to changes in climate and ocean chemistry. Limnology and Oceanography, Methods 6:395–411.

Calvin Kim and Associates, Inc. 1990. Environmental Assessment: Heʻeia Wastewater Collection System. Honolulu, Hawaiʻi.

Carson. 2006 Archaeological Assessment for Replacement of Caretaker's House at Heʻeia Fishpond within Boundary of Site 50-80-10-0327, Heʻeia, Koʻolaupoko District, Oʻahu Island, Hawaiʻi, Portion of Tax Map Key (TMK) 04-06-05:01. IARII, Honolulu.

Char & Associates. 1994. Botanical Survey: HIMB Expansion at Coconut Island, Koʻolau Poko District, Island of Oʻahu. Prepared for Belt Collins Hawaiʻi.

Char & Associates. 1995. Botanical Survey: HIMB Expansion at Coconut Island, Additional Studies.

Clark, J. R. K. 2005. The Beaches of Oʻahu. University of Hawaiʻi Press, Honolulu.

Codiga, D., and K. Wager. 2011. Sea-level Rise and Coastal Land Use in Hawaiʻi: A Policy Tool Kit for State and Local Governments. Center for Island Climate Adaptation and Policy, Honolulu, Hawaiʻi. <http://seagrant.soest.hawaii.edu/sites/default/files/publications/icap-sealevelrisetoolkit_web-1_2.pdf>.

Community Planning and Engineering, Inc. 2014. Final Environmental Assessment: Hawaiʻi Institute of Marine Biology Coconut Island Infrastructure Rehabilitation and Replacement Project, Kāneʻohe, Oʻahu, Hawaiʻi.

Cox, E., and University of Hawai‘i at Mānoa. 2010. Water Quality and Sedimentation Data of the Coastal Intensive Site Network (CISNet) Long-Term Monitoring Sites in Kāne‘ohe Bay, O‘ahu, Hawai‘i from 1998 to 2001. NODC Accession 0001473. National Oceanographic Data Center, NOAA. Dataset. <http://data.nodc.noaa.gov/geoportal/catalog/search/resource/details.page?uuid=%7BE37602C6-4E83-4D48-B5A5-D92D9BB601DD%7D>. Accessed 12 February 2015.

Cruz, B., and H. H. Hammatt. 2012. Cultural Impact Assessment (CIA) for the He‘eia Fishpond Wall Repair Project, He‘eia Ahupua‘a, Ko‘olaupoko Moku, O‘ahu Island. TMK: [1] 4-6-005:001. Cultural Surveys Hawai‘i, Kailua.

Dahl, T. E. 1990. Wetlands Losses in the United States 1790’s to 1980’s. U.S. Fish and Wildlife Service, Washington, D.C.

D’Antonio, C. M., and P. M. Vitousek. 1992. Biological invasion by exotic grasses, the grass/fire cycle, and global change. Annual Review of Ecology and Systematics. 23: 63–87.

[DAR] Division of Aquatic Resources. Unpublished data. Hawai‘i Marine Recreational Fishing Survey. http://dlnr.hawaii.gov/dar/fishing/hmrfs/

DeCarlo, E. H., D. J. Hoover, C. W. Young, R. S. Hoover, F. T. Mackenzie. 2007. Impact of storm runoff from tropical watersheds on coastal water quality and productivity. Applied Geochemistry 22:1777–1797.

[DOFAW] Division of Forestry and Wildlife. Unpublished data. Results of biannual waterbird counts at He‘eia Marsh, O‘ahu, from 1986 to 2004.

Drupp, P., E. H. DeCarlo, F. T. Mackenzie, P. Bienfang, and C. L. Sabine. 2011. Nutrient inputs, phytoplankton response, and CO_2 variations in a semi-enclosed subtropical embayment, Kāne‘ohe Bay, Hawai‘i. Aquatic Geochemistry 17:473–498.

Ducks Unlimited, Inc. 2000. Hawaiian Islands wetlands conservation plan [pamphlet]. Honolulu, Hawai‘i.

Engilis, A., Jr., and M. Naughton. 2004. U.S. Pacific Islands Regional Shorebird Conservation Plan. U.S. Shorebird Conservation Plan. U.S. Department of the Interior, Fish and Wildlife Service, Portland, Oregon.

Englund, R. A., C. Imada, D. J. Preston, and K. Arakaki. 2003. Kāne‘ohe Bay, O‘ahu Stream Estuary Studies. Final Report to Hawai‘i Department of Natural Resources, Division of Aquatic Resources.

[EPA] U.S. Environmental Protection Agency. 2004. STORET Data Warehouse. He‘eia Stream. Station 3-2-08. <http://iaspub.epa.gov/storpubl/storet_wme_pkg.Display_Station?p_org_id=21HI&p_station_id=3-2-08>. Accessed 25 March 2015.

Everson, A. 1994. Fishery Data Collection System for Fishery Utilization Study of Kaneohe Bay Two-Year Interim Report. Hawaii DLNR-Division of Aquatic Resources. Technical Report 94-01.

Everson, A., and A. M. Friedlander. 2004. Catch, Effort, and Yields for Coral Reef Fisheries in Kaneohe Bay, Oahu, and Hanalei Bay, Kauai [unpublished presentation].

Fagan, K. E., and F. T. Mackenzie. 2007. Air-sea CO_2 exchange in a subtropical estuarine-coral reef system, Kāne‘ohe Bay, O‘ahu, Hawai‘i. Marine Chemistry 106:174–191.

Fautin, D., P. Dalton, L. S. Incze, J. Leong, C. Pautzke, A. Rosenberg, P. Sandifer, G. Sedberry, J. W. Tunnell, Jr., and I. Abbott. 2010. An overview of marine biodiversity in United States waters. PLoS One 5:e11914.

Francke, D. L., S. A. Hargrove, E. W. Vetter, C. D. Winn, G. H. Balazs, and K. D. Hyrenbach. 2013. Behavior of juvenile green turtles in a coastal neritic habitat: validating time-depth-temperature records using visual observations. Journal of Experimental Marine Biology and Ecology 444:55—65.

Freeman, S. D. M., and H. H. Hammatt. 2004. Archaeological and Cultural Impact Evaluation for the Proposed Kamehameha Highway Waterline Project, He‘eia, O‘ahu. Cultural Surveys Hawai‘i, Kailua.

Friedlander, A. M., and E. E. DeMartini. 2002. Contrasts in density, size, and biomass of reef fishes between the northwestern and the main Hawaiian islands: the effects of fishing down apex predators. Marine Ecology Progress Series 230:253–264.

Giambelluca, T. W., Q. Chen, A. G. Frazier, J. P. Price, Y. -L. Chen, P. -S. Chu, J. K. Eischeid, and D. M. Delparte. 2013. Online rainfall atlas of Hawai‘i. Bulletin of the American Meteorological Society 94:313–316.

Gombos, M., J. Komoto, K. Lowry, and P. MacGowan. 2010. Hawai‘i Coral Reef Strategy: Priorities for management in the main Hawaiian Islands 2010–2020. State of Hawaii.

Goodman-Lowe, G. 1998. Diet of the Hawaiian monk seal from the Northwestern Hawaiian Islands during 1991–1994. Marine Biology 132:535–546.

Groza, R., and C. Monahan. 2012. Archaeological Literature Review and Field Inspection for the He‘eia Fishpond Wall Repair Project, He‘eia Ahupua‘a, Ko‘olaupoko District, O‘ahu Island, TMK 4-6-005:001. Cultural Surveys Hawai‘i, Kailua.

Guidry, M. W., D. Dumas, F. T. Mackenzie, and E. H. DeCarlo. 2013. Land-Coastal Ocean Interactions in the Tropics and Subtropics: Hawai‘i as an Example. Department of Oceanography, University of Hawai‘i at Mānoa, Honolulu.

Hamburg, N. I., and G. H. Balazs. 2014. Forty Years of Research: Recovery Records of Green Turtles Observed or Originally Tagged at French Frigate Shoals in the Northwestern Hawaiian Islands, 1973–2013. U.S. Department of Commerce, NOAA-TM-NMFS-PIFSC-40.

Helber Hastert & Fee. 2007. He‘eia Fishpond Aquaculture Support Facilities: Final Environmental Assessment, He‘eia, Ko‘olaupoko District. O‘ahu, Hawai‘i.

Henry, L. L. 1993. He‘eia Fishpond Loko I‘a O He‘eia: An Interpretive Guide for the He‘eia State Park Visitor. He‘eia State Park, He‘eia, Hawai‘i.

[HIDOH] Hawai‘i Department of Health. 2014. State of Hawai‘i Water Quality Monitoring and Assessment Report: Integrated Report to the U.S. Environmental Protection Agency and the U.S. Congress Pursuant to §303(d) and §305(b), Clean Water Act (P.L. 97-117). Draft.

[HIMB] Hawai‘i Institute of Marine Biology. 2010. Hawai‘i Institute of Marine Biology Strategic Plan 2010-2015 [Online]. Honolulu, Hawai‘i. <http://hawaii.edu/himb/docs/HIMB_Strategic_Plan_2010_2015.pdf>. Accessed 20 March 2015.

Hoover, D. J., and F. T. Mackenzie. 2009. Fluvial fluxes of water, suspended particulate matter, and nutrients and potential impacts on tropical coastal water biogeochemistry: O‘ahu, Hawai‘i. Aquatic Geochemistry 15:547–570.

Hunter, C. L., and C. W. Evans. 1995. Coral reefs in Kāne‘ohe Bay, Hawai‘i: two centuries of western influence and two decades of data. Bulletin of Marine Science 57(2):501–515.

Hunter, C. L., E. Krauss, and J. Fitzpatrick. 2008. Current and historic distribution and abundance of the inarticulated brachiopod, *Lingula reevii* Davidson (1880), in Kāne‘ohe Bay, O‘ahu, Hawai‘i. Marine Biology 155:205–210.

Jokiel, P. L. 1991. Jokiel's Illustrated Scientific Guide to Kāneʻohe Bay. Hawaiʻi Institute of Marine Biology, Kāneʻohe.

Jokiel, P. L., and E. K. Brown. 2004. Global warming, regional trends and inshore environmental conditions influence coral bleaching in Hawaiʻi. Global Change Biology 10:1627–1641.

Jokiel, P. L., C. L. Hunter, S. Taguchi, and L. Watarai. 1993. Ecological impact of a freshwater "reef kill" in Kāneʻohe Bay, Oʻahu, Hawaiʻi. Coral Reefs 12:177–184.

Jokiel P. L., K. S. Rodgers, I. B. Kuffner, A. J. Andersson, E. F. Cox, and F. T. Mackenzie. 2008. Ocean acidification and calcifying reef organisms: a mesocosm investigation. Coral Reefs 27:473–483.

Kailua Bay Advisory Council. 2007. Koʻolaupoko Watershed Action Strategy. Hawaiʻi's Department of Health ASO Log No. 05-080.

Kawachi, C. 1990. An Archaeological Reconnaissance of Heʻeia Flatlands, Heʻeia, Koʻolaupoko, Oʻahu, TMK 4-6-16:10, 01 por. State Historic Preservation Program, Honolulu.

Kobayashi, K. A. 2001. Heʻeia Coastal Wetland as a Sink for Nitrogen, Phosphorus, and Polychlorinated Biphenyls in Waters Entering Kāneʻohe Bay. Thesis. University of Hawaiʻi at Mānoa, Honolulu.

Koʻolau Mountains Watershed Partnership. 2002. Koʻolau Mountains Watershed Partnership Management Plan. First edition. January.

Kosaka, E. 1990. Technical review of draft report, wetland losses in the United States 1780's to 1980's. U.S. Department of Interior, Fish and Wildlife Service, Washington, D.C.

Krauss, B. H. 1976. Flora and fauna survey of the proposed Heʻeia reservoir and access road. Appendix A *in* Sunn, Low, Tom & Hara, Inc., Revised Environmental Impact Statement for the 1.5 Million Gallon Heʻeia-Kai Reservoir at Heʻeia, Koʻolaupoko, Oʻahu. Prepared for Board of Water Supply City and County of Honolulu, Hawaiʻi.

Kuffner I. B., A. J. Andersson, P. L. Jokiel, K. S. Rodgers, and F. T. Mackenzie. 2008. Decreased abundance of crustose coralline algae due to ocean acidification. Nature Geoscience 1:114–117.

Lamoureux, C. H. 1983. Report on the vegetation and flora of the proposed Heʻeia Kea subdivision. TMK:4-6-16:32. *In* Gray, Hong & Associates, Inc., Revised Environmental Impact Statement for Heʻeia Kea Subdivision, Heʻeia, Koʻolaupoko, Oʻahu. Honolulu, Hawaiʻi.

LeGrande, M. 2006. Botanical resource assessment for the proposed He‘eia Fishpond caretaker’s residence Kāne‘ohe, O‘ahu, Hawai‘i. *In* Helber Hastert & Fee (2007), He‘eia Fishpond Aquaculture Support Facilities: Final Environmental Assessment, He‘eia, Ko‘olaupoko District. O‘ahu, Hawai‘i.

Littnan, C. L., B. S. Stewart, P. K. Yochem, and R. Braun. 2006. Survey for selected pathogens and evaluation of disease risk factors for endangered Hawaiian monk seals in the main Hawaiian Islands. EcoHealth 3(4)232–244.

Maragos, J. E. 1977. Order Scleractinia. Stony Corals. In: Reef and shore fauna of Hawai‘i. Section 1: Protozoa through Ctenophora. Bernice P. Bishop Museum Special Publication 64(1): 158-241.

McAllister, J. G. 1933. Archaeology of O‘ahu. Bishop Museum Bulletin 104. Bishop Museum Bulletin, Honolulu, Hawai‘i.

Mitsch, W. J., B. Bernal, A. M. Nahlik, U. Mander, L. Zhang, C. J. Anderson, S. E. Jorgensen, and H. Brix. 2013. Wetlands, carbon, and climate change. Landscape Ecology 28:583–597.

Nagata, R. H. 1992. Letter to Manabu Tagomori, Administrator, Division of Water and Land Development. Re: Archaeological Concerns Regarding He‘eia Stream Clearing Project, He‘eia State Park, Ko‘olaupoko, O‘ahu, TMK 4-6-05:009, Job No. 85-OP-A1. Division of State Parks, DLNR, Honolulu.

[NOAA] National Oceanic and Atmospheric Administration. 2009. National Environmental Policy Handbook, Version 2.3. Silver Spring, Maryland.

[NOAA] National Oceanic and Atmospheric Administration. 2014. Endangered and threatened wildlife and plants: final listing determinations on proposal to list 66 reef-building coral species and to reclassify elkhorn and staghorn corals. Federal Register 79:53851.

Nurse, L. A., R. F. McLean, J. Agard, L. P. Briguglio, V. Duvat-Magnan, N. Pelesikoti, E. Tompkins, and A. Webb. 2014. Small islands. *In* V. R. Barros, C. B. Field, D. J. Dokken, M. D. Mastrandrea, K. J. Mach, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. O. Estrada, R. C. Genova, et al., editors, Climate Change 2014: Impacts, Adaptation, and Vulnerability—Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom, and New York, New York, USA. <http://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap29_FINAL.pdf>.

[OP] Office of Planning. 1992. Kane‘ohe Bay Master Plan. Office of State Planning, Honolulu, Hawai‘i.

Paepae o He‘eia. 2013. He‘eia Fishpond, He‘eia O‘ahu. The Fishpond. <http://paepaeoheeia.org/thefishpond/>. Accessed 25 March 2015.

Parham, J. E., G. R. Higashi, E. K. Lapp, D. G. K. Kuamo’o, R. T. Nishimoto, S. Hau, J. M. Fitzsimons, D. A. Polhemus, and W. S. Devick 2008. Atlas of Hawaiian Watersheds & Their Aquatic Resources, Island of O‘ahu, Bishop Museum & Division of Aquatic Resources.

Parrish, F. A. 2004. Foraging Landscape of the Hawaiian Monk Seal. Dissertation. University of Hawai‘i, Honolulu.

PBR Hawai‘i. 1993. Final Environmental Impact Statement for the He‘eia State Park Master Development Plan. Honolulu, Hawai‘i.

PBR Hawai‘i. 2007. Final Environmental Impact Statement for the He‘eia State Park Master Development Plan. Honolulu, Hawai‘i.

PBR Hawai‘i. 2014. Hawai‘i NERR Site Nomination Document. Prepared for Hawai‘i State Office of Planning, Honolulu.

Rauzon, M. J., and D. C. Drigot. 2002. Red mangrove eradication and pickleweed control in a Hawaiian wetland, waterbird responses, and lessons learned. Pages 240–248 *in* C. R. Veitch and M. N. Clout, editors, Turning the Tide: The Eradication of Invasive Species. IUCN SSC Invasive Species Specialist Group, IUCN, Switzerland, and Cambridge, United Kingdom.

Ringuet, S., and F. T. Mackenzie. 2005. Controls on nutrient and phytoplankton dynamics during normal flow and storm runoff conditions, southern Kāne‘ohe Bay, Hawai‘i. Estuaries 28:327–337.

Shultz, Kanekoa. Executive Director, Kāko‘o ‘Ōiwi, Kane‘ohe, Hawai‘i. 16 December 2014—conversation with Paul Conry of H. T. Harvey & Associates regarding occurrence of Hawaiian stilt at He‘eia wetlands.

Smith S. V., W. J. Kimmerer, E. A. Laws, R. E. Brock, and T. W. Walsh. 1981. Kāne‘ohe Bay sewage diversion experiment: perspectives on ecosystem responses to nutritional perturbation. Pacific Science 35:279–395.

Solomon, R. F. 2008. Effects of Local Climatic Forcing on CO_2 Dynamics and Air-sea Exchange in Southern Kāne‘ohe Bay, O‘ahu, Hawai‘i. Dissertation. University of Hawai‘i at Mānoa, Honolulu.

Soltz, A. J., P. Lima, and H. H. Hammatt. 2014. Archaeological Inventory Survey for the He‘eia Wetlands Project, He‘eia Ahupua‘a, Ko‘olaupoko District, O‘ahu. TMKs: (1) 4-6-16:001, 002, 004, 011, 012, and 017. Cultural Surveys Hawai‘i, Kailua.

Sterling, E. P., and C. C. Summers. 1978. Sites of O‘ahu. Bishop Museum Press, Honolulu, Hawai‘i.

Sumiye, J. 2002. Ko’olau Mountains Watershed Partnership Management Plan. Prepared for the Ko’olau Mountains Watershed Partnership.

SWCA. 2013. Biological Assessment of Coconut Island Infrastructure Rehabilitation and Replacement Project. Appendix D *in* Community Planning and Engineering Inc. (2014), Final Environmental Assessment: Hawai‘i Institute of Marine Biology Coconut Island Infrastructure Rehabilitation and Replacement Project, Kāne‘ohe, O‘ahu, Hawai‘i.

Taguchi, S., and E. A. Laws. 1987. Patterns and causes of temporal variability in the physiological condition of the phytoplankton community in Kāne‘ohe Bay, Hawai‘i. Journal of Plankton Research 9:1143–1157.

Townscape. 2010. Ko’olau Poko Watershed Management Plan. Public review draft. Prepared for Honolulu Board of Water Supply.

Townscape. 2011a. Kāko‘o ‘Ōiwi Conservation Plan. Windward O‘ahu Soil and Water Conservation District, Aiea, Hawai‘i. Prepared for the Hawai‘i Community Development Authority, Kāne‘ohe, Hawai‘i.

Townscape. 2011b. Application for Coverage under Nationwide Permit 27 for Aquatic Habitat Restoration, Establishment, and Enhancement. Preconstruction Notification and Supporting Documentation for the Māhuahua ‘Ai o Hoi, He‘eia Wetlands Restoration. POH-2010-00159. Kāne‘ohe, Hawai‘i.

U.S. Army Corps of Engineers. 2012. Public Notice of Application for Permit. Hi‘ilei Kawelo, Paepae o He‘eia. Public Notice Date 11 May 2012. POH-2011-00204.

U.S. Climate Data. 2015. Climate Honolulu–Hawai‘i. Honolulu weather averages. <http://www.usclimatedata.com/climate/honolulu/hawaii/united-states/ushi0026>. Accessed 25 March 2015.

[USDA] U.S. Department of Agriculture. 2011. Natural Resources Conservation Service wetland delineation report. Appendix A *in* Townscape (2011b), Application for Coverage under Nationwide Permit 27 for Aquatic Habitat Restoration, Establishment, and Enhancement. Preconstruction

Notification and Supporting Documentation for the Māhuahua ʻAi o Hoi, Heʻeia Wetlands Restoration. POH-2010-00159. Kāneʻohe, Hawaiʻi.

[USFWS] U.S. Fish and Wildlife Service. 2006. Revised Recovery Plan for Hawaiian Forest Birds. Region 1, Portland, Oregon.

[USFWS] U.S. Fish and Wildlife Service. 2011. Recovery Plan for Hawaiian Waterbirds, Second Revision. U.S. Fish and Wildlife Service, Portland, Oregon.

[USFWS] U.S. Fish and Wildlife Service. 2013. Listed Plants Records [Online]. <http://ecos.fws.gov/tess_public/reports/ad-hoc-species-report?kingdom=P&status=E&status=T&status=EmE&status=EmT&status=EXPE&status=EXPN&status=SAE&status=SAT&mapstatus=3&fcrithab=on&fstatus=on&fspecrule=on&finvpop=on&fgroup=on&ffamily=on&header=Listed+Plants> Accessed 22 February 2015.

[USFWS] U.S. Fish and Wildlife Service. 2015a. National Wetlands Inventory Mapper [Online]. Washington, D.C. <http://www.fws.gov/wetlands/>. Accessed 20 February 2015.

[USFWS]. 2015b. Critical Habitat Portal. Critical Habitat Mapper [Online]. Washington, D.C. <http://ecos.fws.gov/crithab/>. Accessed 22 February 2015.

[USFWS and NOAA] U.S. Fish and Wildlife Service and National Marine Fisheries Service. 2015. Endangered and Threatened Species; Identification and Proposed Listing of Eleven Distinct Population Segments of Green Sea Turtles (*Chelonia mydas*) as Endangered or Threatened and Revision of Current Listings; Proposed Rule. Federal Register. Vol. 80, No. 55.

[USGS] U.S. Geological Survey. 2015. National Water Information System: Web Interface—USGS 16275000 Heʻeia Stream at Haʻikū Valley nr Kāneʻohe, Oʻahu, HI. <http://waterdata.usgs.gov/hi/nwis/inventory/?site_no=16275000>. Accessed 26 February 2015.

Ushijima, B., A. Smith, G. S. Aeby, and S. Callahan. 2012. *Vibrio owensii* induces the tissue loss disease montipora white syndrome in the Hawaiian reef coral *Montipora capitata.* PLoS ONE 7(10): e46717.

Weissich, P. 1993. Heʻeia Kea Project: plant list/significant tree. Appendix B *in* PBR Hawaiʻi (2007). Final Environmental Impact Statement for the Heʻeia State Park Master Development Plan. Honolulu, Hawaiʻi.

Williams, I. D, W. J. Walsh, R. E. Schroeder, A. M. Friedlander, B. L. Richards, and K. A. Stamoulis. 2008. Assessing the importance of fishing impacts on Hawaiian coral reef fish assemblages along regional-scale human population gradients. Environmental Conservation, 12 pp.

Windward Community College. 2005. Windward Community College Heʻeia Stream and Kāneʻohe Bay Water Quality Assessment Project, December 2002–2005. Dataset. <https://catalog.data.gov/dataset/windward-community-college-heeia-stream-and-kaneohe-bay-water-quality-assessment-proj-2002-2003> and <https://catalog.data.gov/dataset/windward-community-college-heeia-stream-and-kaneohe-bay-water-quality-assessment-proj-2004-2005>. Accessed 12 February 2015.

Wolff, R. H. 2012. Development of invertebrate community indexes of stream quality for the islands of Maui and Oʻahu, Hawaiʻi. U.S. Geological Survey Scientific Investigations Report 2012-5055.

Woo, M. M. L. 2000. Ecological impacts of the introduced red alga, *Kappaphycus striatum*, in Kāneʻohe Bay, Oʻahu. Dissertation. Botany Department, University of Hawaiʻi, Honolulu.

Yent, M., and A. Griffin. 1977. Results of Archaeological Field Survey in the Interim Development Portions of the Heʻeia-Matson Point State Park. DLNR, Division of State Parks, Honolulu.

Young, C. W., III. 2011. Perturbation of Nutrient Inventories and Phytoplankton Community Composition during Storm Events in a Tropical Coastal System: Heʻeia Fishpond, Oʻahu, Hawaiʻi. Thesis. University of Hawaiʻi at Mānoa, Honolulu.